THURSDAY, JULY 15, 1875

## *SCIENTIFIC WORTHIES*

### V.—George Gabriel Stokes

A GREAT experimental philosopher, of the age just past, is reported to have said, "Show me the scientific man who never made a mistake, and I will show you one who never made a discovery." The implied inference is all but universally correct, but now and then there occur splendid exceptions (such as are commonly said to be requisite to prove a rule), and among these there has been none more notable than the present holder of Newton's chair in Cambridge, George Gabriel Stokes, Secretary of the Royal Society.

To us, who were mere undergraduates when he was elected to the Lucasian Professorship, but who had with mysterious awe speculated on the relative merits of the men of European fame whom we expected to find competing for so high an honour, the election of a young and (to *us*) unknown candidate was a very startling phenomenon. But we were still more startled, a few months afterwards, when the new professor gave public notice that he considered it part of the duties of his office to assist any member of the University in difficulties he might encounter in his mathematical studies. Here was, we thought (in the language which Scott puts into the mouth of Richard Cœur de Lion), "a single knight, fighting against the whole *mêlée* of the tournament." But we soon discovered our mistake, and felt that the undertaking was the effect of an earnest sense of duty on the conscience of a singularly modest, but exceptionally able, and learned man. And, as our own knowledge gradually increased, and we became able to understand his numerous original investigations, we saw more and more clearly that the electors had indeed consulted the best interests of the University; and that the proffer of assistance was something whose benefits were as certain to be tangible and real as any that mere human power and knowledge could guarantee.

And so it has proved. Prof. Stokes may justly be looked upon as in a sense one of the intellectual parents of the present splendid school of Natural Philosophers whom Cambridge has nurtured—the school which numbers in its ranks Sir William Thomson and Prof. Clerk-Maxwell.

All of these, and Stokes also, undoubtedly owe much (more perhaps than they can tell) to the late William Hopkins. He was, indeed, one whose memory will ever be cherished with filial affection by all who were fortunate enough to be his pupils.

But when they were able, as it were, to walk without assistance, they all (more or less wittingly) took Stokes as a model. And the model could not but be a good one: it is all but that of Newton himself. Newton's wonderful combination of mathematical power with experimental skill, without which the Natural Philosopher is but a fragment of what he should be, lives again in his successor. Stokes has attacked many questions of the gravest order of difficulty in pure mathematics, and has carried out delicate and complex experimental researches of the highest originality, alike with splendid success. But several of his greatest triumphs have been won in fields where progress demands that these distinct and rarely associated powers be brought simultaneously into action. For there the mathematician has not merely to save the experimenter from the fruitless labour of pushing his inquiries in directions where he can be sure that (by the processes employed) nothing new is to be learned; he has also to guide him to the exact place at which new knowledge is felt to be both necessary and attainable. It is on this account that few men have ever had so small a percentage of *barren* work, whether mathematical or experimental, as Stokes.

Like that of the majority of true scientific men, his life has been comparatively uneventful. The honours he has won have been many, but they have never been allowed to disturb the patient labour in which short-sighted Britain has permitted (virtually forced) him to waste much of his energies. He was born on August 13, 1819, at Skreen, Co. Sligo, of which parish his father was rector. At the age of 13 years he was sent to Dublin, where he was educated at the school of the Rev. R. H. Wahl, D.D. In 1835 he was removed to Bristol College, of which Dr. Jerrard was principal. He entered Pembroke College, Cambridge, in 1837; graduated in 1841 as Senior Wrangler and First Smith's Prizeman; became Fellow of his College in the same year; and in 1849 was elected Lucasian Professor of Mathematics. In 1857 he vacated his fellowship by marriage, but a few years ago was reinstated under the new statutes of his college. Stokes was elected Fellow of the Royal Society in 1851, was awarded the Rumford Medal in 1852, and was elected Secretary of the Society in 1854.

A really great discoverer in mathematics or physics does not seek the readily-accorded plaudits of the ignorant masses or of the would-be learned rich. He knows the worthlessness of such verdicts (in any but a possible pecuniary sense); his joy is in the conviction that, within a very short time after their publication, his discoveries will be known to all who are really capable of comprehending them; that his experiments will be repeated, and in many cases even extended, by some of them before he has made further advance. He is a true soldier of science, and fights for her cause, not for his own hand; he joys quite as much in an advance made by another as in his own. When the army has passed on from the well-fought field, let the camp-followers deck themselves with frippery from the spoil, and talk pompously of the labours of the campaign! Them the many-headed will applaud, too often even sage rulers will lavishly reward them. The true votary of science, in this country at least, rarely meets with State encouragement and support. Mole-eyed State! Men whose undisturbed leisure would be of incalculable value, not only to the instruction but to the material progress of the nation, have to devote the greater part of their priceless intellects and time to work like common hodmen for their children's bread! It is the long-consecrated, and still common, custom of our mighty empire to harness Pegasus to the dust-cart! Ignorance alone is to blame for this, ignorance that cannot distinguish Pegasus from a jackass!

Perhaps the simile may be thought exaggerated. But what a comment on things as they are is furnished by the spectacle of genius like that of Stokes' wasted on the

drudgery of Secretary to the Commissioners for the University of Cambridge; or of a Lecturer in the School of Mines; or the exhausting labour and totally inadequate remuneration of a Secretary to the Royal Society! Men know about these things, as well as about a good many other important things, much better in Germany than we yet know them; and it will not be very long before we in our turn will be forced to know them to the full as well. Let us hope that this knowledge may come to us in a more gentle form than that of the rude and sudden lessons which have so lately been read (for something very like the same fatal blindness) alike to Austria and to France!

The magnificent Royal Society *Catalogue of Scientific Papers*, one of the greatest boons ever conferred on men of science, shows that up to 1864 Stokes had published the results of some *seventy* distinct investigations; on an average between three and four per annum. Several of these are controversial; designed not so much to establish new results as to upset false and dangerously misleading assertions. Some are improvements on the mathematical methods usually employed in the treatment of comparatively elementary portions of physics; and, especially those on the *Hydrokinetic Equations* and on *Waves*, are exceedingly valuable. These appeared in the *Cambridge and Dublin Mathematical Journal*.

Of the higher purely mathematical papers of Stokes we cannot here attempt to give even a meagre sketch. It would be hopeless to attempt to give the general reader an idea of what is meant by the "Critical Values of the Sums of Periodic Series," or even by the "Numerical Calculation of Definite Integrals and Infinite Series;" though we may simply state that under these heads are included some of the most important improvements which pure mathematics have recently received with the view of fitting them for physical applications.

In applied mathematics it is hard to make a selection, so numerous and so important are Stokes' papers. But we may mention specially the following:—

"On the Friction of Fluids in Motion, and the Equilibrium and Motion of Elastic Solids." *Camb. Phil. Trans.*, 1845.

"On the Effects of the Internal Friction of Fluids on the Motion of Pendulums." *Ibid.* 1850.

(In these papers, for the first time, it is shown how to take account of difference of pressure in different directions in the equations of motion of a viscous fluid; the suspension of globules of water in the air as a cloud is for the first time explained and the vesicular theory utterly exploded; and the notion of Navier and Poisson as to a necessary numerical relation between the rigidity and the compressibility of a solid is shown to be untenable. Each one of these is a distinct, and exceedingly great, advance in science; but they are only single gems chosen, as we happen to recollect them, from a rich treasury.)

Then we have a series of magnificent researches on the "Undulatory Theory of Light," for the most part also published in the *Cambridge Philosophical Transactions*. Of these we need mention only three:—

"On the Dynamical Theory of Diffraction." 1849.

(Here, in addition to a splendid experimental inquiry as to the position of the plane of polarisation with reference to the direction of vibration, we have an invaluable inquiry into the properties and relations of Laplace's Operator, an inquiry bearing not alone upon the Undulatory Theory, but also upon gravity, electric and magnetic attractions, and generally upon all forces whose intensity is inversely as the square of the distance.)

"On the Colours of Thick Plates." 1851.

"On the Formation of the Central Spot of Newton's Rings beyond the Critical Angle." 1848.

As another most important contribution to the undulatory theory we have his

"Report on Double Refraction." *British Association Report*, 1862.

Then we have a full investigation, in one respect carried to a third approximation, of the propagation of waves in water; a complete explanation of the extremely rapid subsidence of ripples by fluid friction, &c.

Another paper of great value is—

"On the Variation of Gravity at the Surface of the Earth." *Camb. Phil. Trans.*, 1849.

Perhaps Stokes is popularly best known by his experimental explanation of *Fluorescence*. This is contained in his paper

"On the Change of the Refrangibility of Light." *Phil. Trans.*, 1852.

There can be no doubt, as was well shown by Sir W. Thomson in his Presidential Address to the British Association at Edinburgh in 1871, that Stokes (at least as early as 1852) had fully apprehended the physical basis of *Spectrum Analysis*, and had pointed out *how* it should be applied to the detection of the constituents of the atmospheres of the sun and stars. Since 1852 Thomson has constantly given this as a part of his annual course of Natural Philosophy in the University of Glasgow; but, till 1859, under the impression that it was quite well known to scientific men. Balfour Stewart's experiments and reasoning date from 1858 only, and those of Kirchhoff from 1859.

In some of Stokes' earlier hydrokinetic papers, he for the first time laid down the essential distinction between rotational, and differentially irrotational, motion, which forms the basis of Helmholtz's magnificent investigations about vortex-motion.

Another most valuable paper (a short abstract of which, in the *Reports of the British Association for* 1857, seems to be all that has been published) completely clears up the difficulties which had been felt with regard to the very curious effects of wind upon sound, and the diffraction of waves in air. The singular fact noticed by Sir John Leslie that the intensity of a sound depends, *ceteris paribus*, to a marked extent upon the nature of the gas in which it is produced, is explained in an admirable manner by Stokes in the *Philosophical Transactions* for 1868 in a paper entitled "On the Communication of Vibration from a Vibrating Body to the surrounding Gas."

Of late years Stokes has not published so many papers as formerly: one reason at least has been already hinted to the reader. But there is another. It is quite well known that he has *in retentis* several optical and other papers of the very highest order, but cannot bear to bring them out in an incomplete or hurried form. No doubt he may occasionally hint at their contents in his lectures, but his (undergraduate) audience are likely to take them for well-known and recognised facts [as Thomson unfortunately did in the case of Spectrum Analysis], and so

they run the risk of being wholly lost—unless independently discovered. But he has not time to draw them up with the last possible improvements, nor to publish that Treatise on Light and Sound which we all so eagerly expect. Hence the world has to wait while the author devotes his powers to work which a clerk could do nearly as well!

Of these later papers, however, that "On the Long Spectrum of the Electric Light," and particularly those on the "Absorption Spectrum of Blood," are of very great value, the latter especially for their physiological applications.

We must not omit to mention that, partly in conjunction with the late Mr. Vernon Harcourt, Stokes has made a most valuable experimental inquiry into what is called *Irrationality of Dispersion*, chiefly with a view to the further improvement of achromatic telescopes.

He has also proved, by very exact measurements, that the wave-surface for the extraordinary ray in uniaxal crystals is (at least to the degree of accuracy of his experiments) rigorously an ellipsoid of revolution. From the theoretical point of view this is a result of extreme importance; and it is a happy illustration of what we have already said as to the conjunction in Stokes of the experimenter and the mathematician.

Several of his papers are devoted to the extraordinary and, at least at first sight, apparently incongruous properties of the Luminiferous Ether—more especially with the view of explaining (on the Undulatory Theory) the observed Law of the Aberration of Light. He has also reaped an early harvest from the even now promising field of the connection between *Absorption* and quasi-metallic *Reflection* of Light—and has furnished the student with an admirably simple investigation of the *Conduction of Heat in Crystals.*

It is quite possible that, in hurriedly jotting down our impressions and recollections of Stokes' work, we may have omitted something of even greater value than we have recorded. But if so, does the fact not show the absolute necessity that exists for a reprint of all Stokes' works, collected alike from the almost inaccessible *Cambridge Philosophical Transactions*, the ponderous *Philosophical Transactions*, &c., no less than from the *Sitzungsberichte* of the Imperial Academy of Vienna, in which we find Stokes suggesting a preservative for miners against the deadly vapour of mercury?

Stokes was President of the British Association at the Exeter meeting in 1869. The Address he then delivered was a thoroughly excellent and appropriate one; and its modest but firm concluding paragraphs are well calculated to reassure those who may have been perplexed or puzzled by the quasi-scientific materialism of the present day.

P. G. TAIT

## SCIENCE EDUCATION FROM BELOW

THE Science Department of the Committee of Council on Education was instituted twenty-two years ago. At that time the general public was far from being alive to its advantages, and for the first seven years it achieved very little. The second term of seven years showed a considerable increase in the number of science schools throughout the country; but it was only during the third septennial period (1867 to 1874) that the importance of such an educational agency became in any sense duly appreciated; and it is not too much to say that it is now one of the most important scientific organisations in this or any country.

Still, in the Government schools as elsewhere, science teaching hitherto has had uphill work, nor must we delude ourselves with the pleasing idea that the road is now all smooth and level. It is true that for some years past the extension of education in this direction has been a popular cry, and a good deal of political capital has been made of it. The international exhibitions have been mainly at the bottom of this; and one of the great benefits derived from those occasions of friendly rivalry has been the diminution of that self-satisfaction which is the greatest bar to progress. Economists have reminded us that we have been relying upon our physical advantages as a nation, rather than the intelligence of our people, in our competition with the rest of the world, and that if we are to maintain our supremacy we must not be behind other nations in the practical applications of knowledge. The argument goes home readily enough to a commercial people, but it is one thing to admit the fact, and another to apply the remedy. The majority of the upper class, from the circumstances of their position and education, are indifferent to the matter. It is foreign to the idea of our older Universities and public schools; and these have exercised, and still continue to exercise, a direct influence over the middle-class schools. True, the number of professional chairs is on the increase, and opportunities are now afforded of practical study in physical and chemical laboratories; but it cannot be pretended that these studies yet take their proper rank amongst the rest. The inferior educational establishments naturally take their cue from the superior ones; indeed, they do so almost as a matter of necessity. They have not only to please the public, but the masters can only impart to their scholars the knowledge they themselves possess; and until on the one hand it be required that the pupils should be taught science, and on the other the masters find it to be an indispensable portion of their educational course, the progress of these studies in private schools will be but slow. In our large towns special teachers can be had for the purpose, but as a fact they are discouraged, the subjects they teach being generally regarded as extras and reduced to a minimum so as not to interfere with the regular routine of the school and the work of the resident masters. So long as the time of the boys is to be wasted in making wretched Latin verses, and the amount of their learning is to be measured by the retentiveness of their memory rather than by how much they understand, the hope of progress in this quarter must inevitably be small.

The operations of the Government department have, however, no direct bearing upon any such schools, unless the principals choose to avail themselves of it as an examining body; but we believe the indirect influence to be already considerable, and likely to become more so in the course of the next few years. Nothing will tend to arouse the proprietors of our boarding schools throughout the land to the necessity of improving both the quantity and quality of the instruction given in them, more than the upward pressure that will be exerted by those who

in a social sense occupy the level immediately below them. The moving impulse is from below, and to that we must now more particularly direct our attention.

From the first the South Kensington establishment has acted as an examining body, and the staff appointed for that purpose includes the names of the most eminent professors in natural and physical science. Subject to certain limitations the passes carry with them pecuniary grants to the authorised local teachers; prizes and medals of honour to the most proficient of the students. The department also makes grants in aid of scholarships and the Royal and local exhibitions, as well as having the administration of those scholarships which were endowed by Sir Joseph Whitworth. Grants are also made in aid of new local schools of science, and towards the cost of the apparatus which they may require. Special classes for the improvement of acting teachers are held by some of the Professors. Lastly, we must not omit to mention in our summary the well-known museum under its management, and the too little known educational library which is available to the general public on payment of a very trifling fee.

The twenty-three branches of study dealt with include Mathematics, Mechanics, Physics, Natural Science, and some of the Applied Sciences. The six most popular among the students are Physical Geography; Pure Mathematics; Animal Physiology; Magnetism and Electricity; Inorganic Chemistry; Acoustics, Light, and Heat: some, such as Navigation and Nautical Astronomy, are, from their very nature, little studied except in special localities. The large preponderance of students in Physical Geography, generally nearly double that of the next in rank, is due to girls' schools, in which it forms a leading feature, being included.

Those who care for statistics will be interested in the following table, for which we are indebted to the courtesy of the Secretary of the Science and Art Department. The table shows the actual state of the Science Classes in Great Britain during the last session.

| — | I.—Practical Plane and Solid Geometry. | II.—Machine Construction and Drawing. | III.—Building Construction. | IV.—Naval Architecture. | V.—Mathematics. Stages 1, 2, 3. | V.—Mathematics. Stages 4, 5. | V.—Mathematics. Stages 6, 7. | VI.—Theoretical Mechanics. | VII.—Applied Mechanics. | VIII.—Acoustics, Light, and Heat. | IX.—Magnetism and Electricity. | X.—Inorganic Chemistry. | XI.—Organic Chemistry. | XII.—Geology. | XIII.—Mineralogy. | XIV.—Animal Physiology. | XV.—Elementary Botany. | XVI. and XVII.—General Biology. | XVIII.—Principles of Mining. | XIX.—Metallurgy. | XX.—Navigation. | XXI.—Nautical Astronomy. | XXII.—Steam. | XXIII.—Physical Geography. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Classes. | 211 | 248 | 181 | 12 | 537 | 18 | 5 | 105 | 66 | 357 | 485 | 322 | 49 | 162 | 15 | 414 | 66 | 35 | 6 | 10 | 32 | 9 | 73 | 686 |
| No. of Students. | 4631 | 5201 | 2518 | 183 | 10502 | 251 | 23 | 2265 | 1238 | 8463 | 12515 | 8259 | 701 | 3183 | 307 | 9470 | 1914 | 547 | 110 | 110 | 537 | 236 | 1260 | 17720 |
| Students examined. | 2500 | 3968 | 1302 | 117 | 6228 | 121 | 21 | 1668 | 704 | 5473 | 9122 | 5264 | 286 | 2598 | 116 | 6623 | 1168 | 209 | 95 | 173 | 251 | 92 | 908 | 13312 |

The students for whom this machinery is designed belong to what may be termed the Industrial Classes, including all those in receipt of weekly wages, small tradesmen whose income does not exceed 200*l*. per annum, the children of any of these, all attendants at Public Elementary Schools, together with the teachers and pupil teachers of such, and the students in the Training Colleges which receive grants from the Education Department. This list of course includes such as constitute our mechanics' institutes and co-operative societies, in the programmes of which science classes now form an important element. In these the practical advantages are of a most direct character; but we are disposed to ascribe a still higher value to the assistance rendered in the Training Colleges and to the acting and pupil teachers in the Public Elementary Schools. Hitherto one of the difficulties which the department has had to contend against has arisen from the unavoidable circumstance that so many of the local science teachers are themselves self-taught, and their deficiencies have often been only too apparent in the character of the examination papers given in by their pupils: time, however, will do much to cure this as these teachers drop into the background and are succeeded by those who have gone through a systematic training.

The next table will show the rapid extension of the operations of the department during the years 1867 to 1873 inclusive. It will be seen, on comparing the figures, that the relative number of those who now go up for examination is greater than formerly, and that the increase in the number of papers worked is still greater in proportion.

| Year. | Number of Science Scholars. | Number who went up for Examination. | Number of Examination Papers worked by them. | Number of Papers passed. |
|---|---|---|---|---|
| 1867 | 10,230 | 4,520 | 8,213 | 6,013 |
| 1868 | 15,010 | 7,092 | 13,112 | 8,649 |
| 1869 | 24,865 | 13,234 | 24,085 | 14,550 |
| 1870 | 34,283 | 16,515 | 34,413 | 18,690 |
| 1871 | 38,015 | 18,750 | 38,098 | 22,105 |
| 1872 | 36,783 | 19,568 | 39,383 | 27,806 |
| 1873 | 48,546 | 24,674 | 56,577 | 35,100 |

It is abundantly clear then that through the enlightened and vigorous action of the Science and Art Department, a large bulk of the population of our country has received and is receiving an elementary scientific education. The work which Sir Henry Cole began can no longer be sneered at nor overlooked; its value to this country is beginning to be widely recognised, and the man who laid its foundations so wisely and well deserves the highest gratitude of his countrymen. Let us remember that only a few years ago there was little science education in the higher classes, and absolutely none in the lower; whereas, scattered over Great Britain, there are in active work this year no less than 1,707 certificated science teachers engaged in 1,374 science schools, teaching 4,104 separate classes, and the number of individuals actually receiving science instruction by this means reaches the enormous total of 48,274.

The Department, however, has not been content to rest on its laurels. Within the last few years it has undertaken a new work, which promises to be of the highest value. It was felt that the system of examinations needed supplementing. Teachers could gain certificates, and thus receive payment upon the results of their teaching, without any evidence of their having more than book knowledge. And it was found, indeed, that the great body of certificated teachers had, with few exceptions, little practical knowledge of the various subjects they taught. They could accurately describe an electrophorus, but they could not make one, nor use it perhaps when made; they knew all about the circulation of the blood or the structure of the heart, but they had never seen the one nor dissected the other. For the most part they knew nature as words, not as living facts. The eminent men who conduct the examinations for the Department saw the danger that was arising. Prof. Huxley addressed the Government upon the subject, and urged a practical class in Physiology for a certain number of science teachers certificated in that subject. By taking fresh men each year it was hoped that a large amount of practical knowledge would be diffused and gradually make its way through the various science classes. The late Government promptly acceded to the wish thus expressed, and in 1869 two short practical courses of a week each were given, the one on Animal Physiology and the other on Light.

The importance of even such brief instruction was so manifest that it was decided to enlarge the original conception. The details of the scheme were, however, difficult and needed to be grappled with in earnest. The body of teachers was large and distributed over wide areas; they could not afford the time nor money to come to London for instruction, and even if they had the requisite knowledge their means were too slender to enable them to purchase the apparatus needed for the proper demonstration of their subject. To the administrative genius of Major Donelly, the present chief of the Science Staff at South Kensington, no less than to his untiring zeal in the cause of scientific education, the country is mainly indebted for the solution of this formidable difficulty. Announcements were made to all the certificated science teachers throughout the country that a month or six weeks' gratuitous course of daily practical instruction, in various branches of experimental science, would be held at the new Science Schools at South Kensington during the summer vacation. Those who wished for this instruction were to apply to the Department; if selected, their expenses to and from London would be paid, and thirty shillings a week given to each as a maintenance allowance whilst they remained in London. It was soon found impossible to accommodate all who applied; at present the applications are about three times as many as can be taken. In the selection of the men most needing this kind of instruction, and who would afterwards make the best use of it, arose another difficulty. But, as before, the excellent judgment of the Secretary of the Science and Art Department, and the careful scrutiny of his officers, led to a choice of such capital men that the wisdom of their mode of selection has been shown in the happiest manner.

At the present moment sixty teachers are working at Practical Chemistry under Prof. Frankland and Mr. Valentin; thirty-one teachers are studying Heat practically under Prof. Guthrie; these have been preceded by the same number who have worked at Light; twenty-one are studying Mechanics with Professors Goodeve and Shelley; twenty-eight are being taught Geometrical Drawing by Prof. Bradley; and thirty-eight are working at Machine Construction and Drawing under Prof. Unwin.

The applicants give a list of the courses they wish to attend, in much the same way that one hands in a selected list of books to Mudie's Library; they are allotted courses as far as possible in their order of preference, and may, in successive years, take successive subjects. The courses only last from three to six weeks. Chemistry this year runs on from the 1st to the 23rd of July; Physics, from June 23rd to Aug. 3rd; Mechanics and Geometrical Drawing from June 30th to July 22nd; and Machine Construction from 27th July to 13th of August. It might be imagined that such short courses could be of little real use; experience has, however, shown the reverse. The fact is, the men in each subject are thirsting for information, they know they have now a chance which may never recur to them; in a few short weeks they must strive to win much knowledge, which they not only desire for its own sake, but which means bread and cheese to their families. They are prompted, therefore, by every inducement to make the best possible use of their time. It is this heartiness of work combined with the admirable system of instruction given by each professor that has made these short summer courses so remarkably effective.

Capital evidence of the value of what is being done may be had by simply walking through the different rooms of the Science Schools and observing the teachers at work. If, for example, we go into the Biological department,* we find every man busily dissecting plants or animals, each one seated at a separate little table, and each provided with an excellent microscope and proper instruments and suitable specimens. The earnestness of everybody in the room strikes one very forcibly; and as we look at the fresh specimens at every table, we think of the labour implied in choosing typical objects and securing forty or fifty of each daily. Professors and students unquestionably are hard at work. If we now go into the fine chemical laboratories a like impression is produced. Here are one set making perhaps their first

practical acquaintance with the reactions which they have so often written down, and which in future they will regard with an altogether new interest and delight. Others more advanced are conducting analyses, or perhaps making "combustions"—if in the advanced group, studying organic chemistry. All are intensely busy, and work with a fixed purpose before them. The same quiet activity is noticeable in the different subjects going on in the other rooms. Entering last the physical laboratory on the ground floor, we find the teachers constructing apparatus which, though simple and often rough, is well adapted for teaching purposes. The raw material is provided them, printed instructions are given to each one, and under the direction of Prof. Guthrie, and the gentlemen associated with him, the most useful physical instruments are built up. These instruments are then employed in repeating the experiments seen in the morning lecture, or in making physical measurements wherever it is possible to do so. The homely apparatus, it is true, has not the polish of the instrument-maker, but in delicacy and efficiency is, generally speaking, far better than the teachers could purchase out of the small grants allowed to them for that purpose. With a wise liberality the Department permits each teacher to take home with him, without any charge, all the apparatus he himself has made: and one can easily imagine the pleasure with which these simple and useful instruments are afterwards looked upon and used by those who have made them. Nor is this all; the impulse to sound and practical science teaching is given, and at the same time the hands have been disciplined to useful skill, and the senses trained to accurate observation. After such preparation good use is made by the teachers of the more refined physical instruments which are set before them, but which are beyond their time or power to construct for themselves. It is most instructive to watch one of these men as he makes his first essay, and to trace the growth of his education in manipulative skill and in practical knowledge of his subject. We propose in our next number to go more fully into detail in this matter, and to describe some of the simple physical apparatus made by the teachers.

But the good work done by the Department does not rest here. In addition to giving practical instruction to teachers in short summer courses, free admission to extended courses of lectures and practical instruction in Chemistry, Physics, Mechanics, and Biology at South Kensington was granted to a limited number of teachers and students who intended to become science teachers. The selected candidates received a travelling allowance, and a maintenance allowance of 25*s.* a week while in London. The courses in Chemistry and Biology commenced in October of last year and ended in the early spring, when the courses in Physics and Mechanics began, and these closed at the beginning of this summer. From ten to sixteen teachers in training attended these different classes, and worked daily from 10 to 5 at the subjects they had chosen, in the evening writing up their notes and memoranda. Botany was not included in the foregoing series, but it was not forgotten. In January last the Lords of the Committee of Council on Education gave directions for a practical course on this subject. The course was given by Prof. Thiselton Dyer, and commenced on the 4th of March last, extending over eight weeks. It was attended by twenty-three science teachers and persons intending to become science teachers; these received precisely the same advantages as the teachers in training in the other subjects.

* This refers to last year; the teachers' summer course on Biology has been omitted this session.

The value of such courses as these can hardly be overestimated, and we trust that no niggardly policy will lead the Government to restrict the great and good work they have begun. We hope there is no cause for apprehension in the apparent neglect of Biology in the summer course given this year, and what seems to us a little diminution of the strength of the staff in another subject. The improvement in the quality of the education given by the science teachers is already making itself felt. The reports of the May examiners for recent years show that "while the general average has been maintained throughout, the instruction had in some subjects decidedly improved." But it will necessarily take a few years to lift up so large a constituency. Surely and slowly it is being done, and the masses of the country are gaining a sound elementary knowledge of science. Whilst the magnificent laboratories of the Universities of Oxford and Cambridge and Dublin are nearly empty, Owens College and the classes under the Department are crowded with active and earnest workers.

The several large educational societies of England have availed themselves for some years past of the benefits offered by the Science and Art Department, with the object of turning the students out of their Training Colleges as thoroughly fitted as possible for their future scholastic career; and the continuance of this system for the future is now further assured by the necessity of their being provided with Government certificates in science in order to secure employment under the London School Board, or indeed at any of the first-class Elementary Schools throughout the country.

An impartial view of the facts we have placed before our readers will show that what the Universities might have done from above, others are doing from beneath. Science, instead of forming the delightful pursuit of the leisure classes, and thence distilling downwards to the workers, is, on the contrary, first becoming an integral part of the education of the toilers of the country. England, in fact, is being scientifically educated from below.

## DARWIN ON CARNIVOROUS PLANTS

### I.

*Insectivorous Plants.* By Charles Darwin, M.A., F.R.S., &c. With Illustrations. (London: J. Murray, 1875.)

TO have predicted, after the publication of Mr. Darwin's works on the Fertilisation of Orchids and the Movements and Habits of Climbing Plants, that the same writer would hereafter produce a still more valuable contribution to botanical literature, characterised to an even greater extent by laborious industry and critical powers of observation, and solving or suggesting yet more important physiological problems, would have seemed the height of rashness. And yet, had such a prediction been made, it would have been amply justified by the present

volume, one which would alone have established the reputation of any other author, and which will go far to redeem our country from the charge of sterility in physiological work. Much attention has been called recently to the singular subject of "carnivorous plants;" we have had records of useful original work from several quarters in England, the Continent, and America, together with much that has been superficial and worthless; and even the newspapers have discussed the anti-vegetarian habits of some vegetables in the light, airy, and philistine manner in which they are wont to approach "mere scientific" subjects. During the whole of this time, for the last fifteen years, Mr. Darwin has been steadily and quietly at work, collecting materials and recording long series of observations; and now at length has given us their results, completely and finally settling some of the points that have been most in controversy, and raising others which suggest conclusions that will take by surprise even those whose minds have been most open to deviate from the old and narrow paths.

Rather more than one-half of the volume is devoted to the most abundant and readily obtainable of these predatory plants, the common Sundew, *Drosera rotundifolia;* and an epitome of this portion must be first placed before our readers.

Commencing with a description of the well-known leaves and their glandular appendages, or "tentacles," as he terms them, Mr. Darwin has arrived at the conclusion that these latter most probably existed primordially as glandular hairs or mere epidermal formations (trichomes), and that their upper part should still be so considered; but that their lower portion, which alone is capable of movement, consists of a prolongation of the leaf; the spiral vessels being extended from this to the uppermost part. One point which seems to be clearly established is, that it is not sufficient that the substance which excites the movements of the tentacles should merely rest on the viscid fluid excreted from the glands; it must be in actual contact with the gland itself. A statement made by several previous observers (including Prof. Asa Gray on the authority of Mr. Darwin's earlier observations, and the present writer)—that inorganic substances are almost or entirely without effect in producing movement—must now be modified. Although the effect is much less considerable, and the substance is soon released from the embrace of the tentacles; yet such bodies as minute particles of glass undoubtedly possess the power of irritation. While it is the glands or knobs at the extremities of the tentacles, and a very small part of the upper portion of the pedicels, which alone are sensitive or irritable, the actual inflection takes place only in the lowermost portion of the pedicel, causing a bending of the tentacle; and the irritation is conducted from the tentacle actually excited to the neighbouring ones, or to all those on the leaf, in such a manner as to cause them to bend towards the object which produces the excitement. One of the most striking of the series of observations here recorded is that which describes the affixing of exciting particles on glands at two different portions of a leaf of *Drosera*, the result being that all the tentacles near each of these two points were directed towards them, "so that two wheels were formed on the disc of the same leaf, the pedicels of the tentacles forming the spokes, and the glands united in a mass" over the irritated tentacle which represented the axle; the precision with which each tentacle pointed to the irritating particle was wonderful. What makes this result the more extraordinary is that "some of the tentacles on the disc, which would have been directed to the centre had the leaf been immersed in an exciting fluid (as in Fig. 1), were now inflected in an exactly opposite direction, viz., towards the circumference. These tentacles, therefore, had deviated as much as 180° from the direction which they would have assumed if their own glands had been stimulated, and which may be considered as the normal one." As the author remarks, "we might imagine that we were looking at a lowly organised animal seizing prey with its arms." Indeed, the whole description of Mr. Darwin's researches after the tissue that conducts this irritation reminds one of experiments on the motor and sensitive nerves of animals; and we commend the subject to the serious attention of the Royal Commission now sitting to investigate the subject of vivisection. Mr. Darwin compares this movement to the curvature displayed by many tendrils towards the side which is touched; but the comparison appears to us to fail, from the fact that the movement of tendrils is a function of growth, they being sensitive to contact or pressure only so long as they are in a growing state; which is not the case with the tentacles of *Drosera*. One of the most extraordinary of the statements made by trustworthy observers with regard to the sensitiveness of these tentacles is not, however, confirmed by Mr. Darwin. Mrs. Treat (*American Naturalist*, Dec. 1873) asserts that when a living fly was pinned at a distance of half an inch from the leaves of the American species *D. filiformis*, the leaves bent towards it and reached it in an hour and twenty minutes, a phenomenon inexplicable on any theory which would account for the transmission of the irritation from one tentacle to another. Mr. Darwin states, on the contrary, that when pieces of raw meat were stuck on needles and fixed as close as possible to the leaves, but without actual contact, no effect whatever was produced. The minuteness of the solid particles which produced sensible inflection was a matter of great surprise. Particles perfectly inappreciable by the most sensitive parts of the human body, as the tip of the tongue—a fragment of cotton weighing $\frac{1}{8000}$, and of hair weighing $\frac{1}{78000}$ of a grain—caused the tentacles with which they were in contact to bend. Our author remarks that "it is extremely doubtful whether any nerve in the human body, even if in an inflamed condition, would be in any way affected by such a particle supported in a dense fluid, and slowly brought into contact with the nerve; yet the cells of the glands of *Drosera* are thus excited to transmit a motor impulse to a distant point, inducing movement;" and he adds justly, that "hardly any more remarkable fact than this has been observed in the vegetable kingdom." The only substance which appears to be altogether without effect in producing inflection is drops of rain-water; a singular exception paralleled by the case of certain climbing plants whose excessively sensitive tendrils are irritable to every sort of object which touches them except rain-drops.

The inflection of the base of the tentacle is accompanied by a change in the molecular condition of the

protoplasmic contents of the cells of the gland and of those lying immediately beneath it; though the two phenomena are not necessarily connected with one another. If the tentacles of a young but mature leaf that has never been excited or become inflected, are examined, the cells forming the pedicels are seen to be filled with a homogeneous purple fluid, the walls being lined with a layer of colourless circulating protoplasm. If a tentacle is examined some hours after the gland has been excited by repeated touches, or by an inorganic or organic particle placed on it, or by the absorption of certain fluids, the purple matter is found to be aggregated into masses of various shapes suspended in a nearly or quite colourless fluid. This change commences within the glands, and travels gradually down the tentacles; and the aggregated masses of coloured protoplasm are perpetually changing

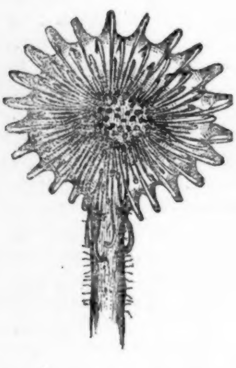


FIG. 1.—(*Drosera rotundifolia.*) Leaf (enlarged) with all the tentacles closely inflected, from immersion in a solution of phosphate of ammonia (one part to 87,500 of water).

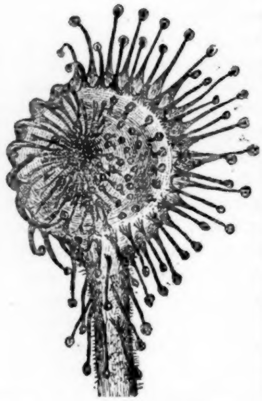


FIG. 2. —(*Drosera rotundifolia.*) Leaf (enlarged) with the tentacles on one side inflected over a bit of meat placed on the disc.

their form, separating, and again uniting. Shortly after the tentacles have re-expanded in consequence of the removal of the exciting substance, these little coloured masses of protoplasm are all re-dissolved, and the purple fluid within the cells becomes as homogeneous and transparent as it was at first. This process of aggregation is independent of the inflection of the tentacles and of increased secretion from the glands; it commences within the glands, and is transmitted from cell to cell down the whole length of the tentacles, being arrested for a short time at each transverse cell-wall. The most remarkable part of the phenomenon is that even in those tentacles which are inflected, not by the direct irritation of their glands, but by an irritation conducted from other glands on the leaf, this aggregation of the protoplasm still commences in the cells of the gland itself.

Some who admit the reality of the phenomena now described, have still doubted the digestive power ascribed to the leaves of the Sundew, believing that the apparent absorption of the organic substances in contact with the glands is due rather to their natural decay. This question is, however, entirely set at rest by Mr. Darwin's observations. The action of the secretion from the glands on all albuminous substances—for it is by these only among fluids that inflection of the tentacles is excited—is precisely the same as that of the gastric juice of animals. The secretion of the unexcited glands is neutral to test-papers; after irritation for a sufficiently long period it is distinctly acid. A very careful analysis by Prof. Frankland of the acid thus produced indicated that it was probably propionic, possibly mixed with acetic and

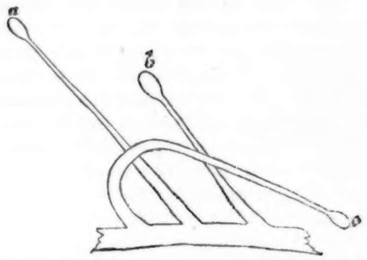



FIG. 3.—(*Drosera rotundifolia.*) Diagram showing one of the exterior tentacles closely inflected; the two adjoining ones in their ordinary position.

butyric acids; and the fluid, when acidified by sulphuric acid, emitted a powerful odour similar to that of pepsin. If an alkali is added to the fluid, the process of digestion is stopped, but immediately recommences as soon as the alkali is neutralised by weak hydrochloric acid. Mr. Darwin believes that a ferment of a nature resembling that of pepsin is secreted by the glands, but not until they are excited by the absorption of a minute quantity of already soluble animal matter; a conclusion which is confirmed by the remarkable fact observed by Dr. Hooker, that the fluid secreted by the pitchers of *Nepenthes* entirely loses its power of digestion when removed from

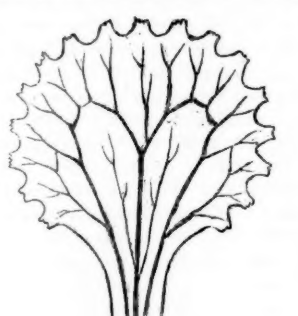


FIG. 4.—(*Drosera rotundifolia.*) Diagram showing the distribution of the vascular tissue in a small leaf.

the pitcher in which it is produced. It is one of the many extraordinary facts connected with this subject that the tentacles of the leaves of *Drosera* retain their power of inflection and digestion long after the separation of the leaves from their parent plant.

As might naturally be expected, salts of ammonia are among the substances which have the most powerful effect on the leaves of *Drosera;* but the excessively minute quantities which are efficacious will probably be

as astonishing to everyone else as they were to Mr. Darwin himself. From a most carefully conducted series of experiments from which every possible source of error seems to have been eliminated, it appears that the absorption by a gland of $\frac{1}{268800}$ of a grain of carbonate of ammonia (this salt producing no effect when absorbed through the root) is sufficient to excite inflection and aggregation of the protoplasm. With nitrate of ammonia a similar effect is produced by the $\frac{1}{691200}$ of a grain; while the incredibly small quantity of $\frac{1}{19760000}$ of a grain of phosphate of ammonia produces a like effect. Mr. Darwin believes that carbonate of ammonia is also absorbed in the gaseous state by the tentacles; but we venture to think that the evidence on this point is not conclusive. In both the experiments which he records the air surrounding the plant was more or less humid, and the effect was much more intense in the one where the air was the dampest, indicating apparently that the inflection was due to the absorption of the extremely soluble gas by the moisture which was in contact with the tentacles. This would also afford an explanation of what he regards as "a curious fact, that some of the closely adjoining tentacles on the same leaf were much, and some apparently not in the least, affected," if we suppose that they were clothed with larger and smaller amounts of moisture. The view that the glands have no power of absorbing gases or effluvia receives confirmation from the failure of the attempt to induce inflection or aggregation by the affixing of particles of meat in close proximity to the tentacles, but without actual contact.

We cannot follow Mr. Darwin through his exhaustive series of experiments on the effects of various solutions of mineral salts, acids, and poisons, on the leaves of *Drosera.* With organic fluids the aggregation of the protoplasm and inflection of the tentacles furnish a most delicate and unerring test of the presence of nitrogen. The effect of inorganic salts and poisons can by no means be inferred from the effect of the same substances on living animals, nor from their chemical affinity. Nine salts of sodium all produced inflection, and were not poisonous except when given in large doses; while seven of the corresponding salts of potassium did not cause inflection, and some of these were poisonous. This corresponds to the statement of Dr. Burdon Sanderson, that sodium salts may be introduced in large quantities into the circulation of mammals without any injurious effects, whilst small doses of potassium salts cause death by suddenly arresting the movements of the heart. Benzoic acid, even when so weak as to be scarcely acid to the taste, acts with great rapidity and is highly poisonous to *Drosera*, although it is without marked effect on the animal economy. The poison of the cobra, on the other hand, so deadly to all animals, is not at all poisonous to *Drosera*, although it causes strong and rapid inflection of the tentacles, and soon discharges all colour from the glands.

The last point of investigation is the mode of transmission and nature of the conducting tissue of the motor impulse from one tentacle to another. It has been already stated that the seat of irritability is limited to the glands themselves and a few of the uppermost cells of the pedicels, the blade of the leaf itself not being sensitive to any stimulant. In order to be conveyed from one tentacle to another, the impulse has therefore to be transmitted down nearly the whole length of the pedicel; and it appears to be conveyed from any single gland or small group of glands through the blade to the other tentacles more readily and effectually in a longitudinal than in a transverse direction. It can be shown that impulses proceeding from a number of glands strengthen one another, spread further, and act on a larger number of tentacles than the impulse from any single gland. The phenomenon already alluded to, of the aggregation of the protoplasm in a tentacle incited indirectly by the irritation of other glands on the leaf—this aggregation advancing not upwards, but downwards, in each tentacle—is spoken of by Mr. Darwin as partaking of the nature of those actions which in the nervous systems of animals are called reflex. The existence of such a phenomenon—of which this is the only known instance in the vegetable kingdom—is one of the most extraordinary points brought out by these investigations. It will be recollected that the transmission of the motor impulse in the sensitive leaves of *Mimosa* is in a precisely opposite direction, travelling upwards from the base to the apex of those pinnæ which are indirectly irritated in consequence of the direct irritation of other pinnæ of the same leaf. The arrangement and direction of the fibro-vascular bundles in the leaves of *Drosera* are shown in Fig. 4; and Mr. Darwin's inquiries were first directed to solve the question whether the impulse was conveyed through the vascular system; but he came to the conclusion that it is not sent, at least exclusively, through the spiral vessels or through the tissue immediately surrounding them. He believes, on the contrary, that the conducting tissue is the parenchyma or cellular tissue of the mesophyll of the leaf; and that it is chiefly delayed by the obstruction offered by the cell-walls through which it has to pass; the transmission of the impulse being indicated by the phenomenon of aggregation of the protoplasm, which is transmitted gradually from cell to cell.

A few other species of *Drosera* were examined, but presented no special phenomena of interest; and the remainder of the volume is occupied by the narrative of researches on other carnivorous plants, a review of which we must defer to a future number.

ALFRED W. BENNETT

(*To be continued.*)

## *PERCY'S METALLURGY*

*Metallurgy: Introduction, Refractory Materials and Fuel.* By John Percy, M.D., F.R.S. (London: J. Murray, 1875).

THIS valuable work is not merely a new edition of the volume previously published by its distinguished author, for it contains more than 350 pages of fresh matter, and several articles on subjects which were not treated of originally. Dr. Percy's "Metallurgy" is so well known as the standard book in this country that it may be well to indicate as succinctly as possible the differences between the present volume and the portion of the one published in 1861, which was devoted to refractory materials and fuel.

Much information has been added to the section which

treats of the physical properties of metals. Thus a general but comprehensive view of the subject of Elasticity is given, with ample references to the works of Wertheim, Kupffer, Styffe, and others. Tresca's experiments on the flow of metals are also briefly described, and "Tensile strength" has received due attention. Graham's experiments on the occlusion of gases by metals are described at some length.

The matter relating to the composition, fusibility, and character of slags, has been re-arranged.

As plumbago crucibles are now so extensively used, the question of the suitability of different kinds of graphite for their manufacture has become of much importance. A valuable table of analyses of graphite of various qualities from different localities is therefore given, and the machinery used by Messrs. Morgan in their well-known crucible works is illustrated by excellent drawings. The apparatus devised by Ste. Claire Deville for obtaining high temperatures is now frequently employed in laboratories, and the description of the methods of making the crucibles of carbon, lime, magnesia, alumina, and bauxite will be of much service. Deville's blast furnace is described, but we could have wished that, in the interests of metallurgical research, some account had been given in this place of the oxyhydrogen blowpipe, and of the apparatus by means of which he melted platinum.

Care has been taken to collect the recently discovered facts relative to the calorific power and calorific intensity of fuel, and these are specially considered with reference to furnace temperatures. The section devoted to Pyrometry is excellent, and Weinholt's classification of the principles on which the instruments have been constructed has been adopted.

The question of the utilisation of peat and of the possibility of substituting it for coal in metallurgical and other manufacturing processes, has of late particularly engaged public attention in this country. Dr. Percy has therefore collected "such evidence as may enable the reader to arrive at a satisfactory judgment on that question," and forty-six pages are devoted to the consideration of cutting peat, together with its mechanical treatment, condensation, and desiccation. We may quote some of Dr. Percy's general conclusions as to its use as fuel. He observes that, "so far as the suitability of peat for metallurgical purposes is concerned, we may not unreasonably conclude that it could be widely substituted for coal with success;" but he states as his conviction that peat can only compete with coal in countries where the cost of production and carriage of peat is relatively very low and the price of coal is relatively very high.

More than 200 analyses of coal from various parts of the world are given, and we may mention as an indication of the care which has been taken to render the section devoted to coal as complete as possible, that Von Meyer's recent investigations as to the nature of the gases disengaged from certain varieties, and Fleck's table showing the action of weathering on the chemical composition of coal, are recorded at some length. Valuable remarks as to the various sources of error in the analysis of coal are given, but we venture to think that students would have been grateful for some account of the methods of analysis and details of manipulation.

The author next treats of charcoal, and an account of Dromart's process for charring in circular piles by firing at the bottom has been added to the descriptions of the various processes contained in the former volume. Reference is also made to the methods of preparing brown charcoal and "torrefied wood," and the section concludes with theoretical considerations concerning their use.

In the new matter relative to coke, the various methods of desulphurisation are treated at some length, and, in considering the economic products generated during coking, Dr. Percy gives much evidence as to the working of Pernolet's oven; but he concludes, as in the case of many other metallurgical operations, by pointing out that the evidence as to the advantages of the process "is not a little conflicting." A new article has been added on the preparation of peat-charcoal, with reference to the employment of which the author observes "that as yet the use of peat-charcoal in metallurgical operations in Great Britain is either very restricted or must be kept rigidly secret."

The consideration of one or two questions of practical importance in connection with the subject of fuel is reserved for the conclusion of the volume.

The author, in treating of the preparation of peat for fuel, makes some observations on patents generally which deserve notice. He says: "Should any person of ordinary intelligence be disposed to wade through the dreary specifications of patents relating to the preparation of peat for fuel, he will perceive that frequently the same thing has been patented several times, and that in not a few cases the patentees have displayed astounding ignorance of the subject." He suggests as a remedy that "a tribunal for the administration of patent law" should be established. "The expenses of such a tribunal could be defrayed . . . . out of the large *surplus* income, exceeding 50,000*l.*, arising from the duties and fees paid by patentees." The authority of such a court would doubtless have a very beneficial effect; but we may point out that the sum above named would probably be very materially reduced by its intervention, and that the vigilance and remuneration of the tribunal might each tend to diminish the other. Dr. Percy calls attention to the scheme proposed during the present session by the Lord Chancellor, who suggests the appointment of five additional commissioners of patents, without giving them any remuneration whatever for their services!

Among the illustrations are plans and sections of Ekman's peat kiln, of Echement's pile for making brown charcoal, and at the end of the volume there are nine folding plates, some of them coloured, giving complete working drawings of Siemens' gas producer and regenerative gas reheating furnace, and of Coppée's coke oven, in which even the forms and dimensions of the fire-bricks are shown. The drawings throughout the volume are admirable, and, as is the case in all Dr. Percy's works, are drawn to scale.

We think that it is a matter for congratulation that the author's labours have been devoted to rendering the introduction to Metallurgy as complete as possible, before considering metals not yet touched upon, which would doubtless have been more attractive work. Throughout this, as in former volumes, the slightest aid has been carefully acknowledged, and the relative merits of discoverers are most conscientiously apportioned, in Dr.

Percy's remarks, which are sometimes severe but always impartial.

In viewing the volume in relation to metallurgical science generally, we are reminded of a remark made by Dumas more than twenty years ago: "Les nouvelles substances métalliques ne méritent certes pas l'oubli dans lequel les chimistes les laissent depuis si longtemps." We fear that the words apply with some force to the state of metallurgical *research* at the present day; still, the progress which has been made is very considerable, and this country has good reason to be proud of Dr. Percy's contributions to the literature of the subject.

## OUR BOOK SHELF

*Sound.* By John Tyndall, D.C.L., LL.D., F.R.S., Professor of Natural Philosophy in the Royal Institution of Great Britain. Third Edition. (London: Longman and Co., 1875.)

THE principal addition to this new edition of Dr. Tyndall's work on Sound is an account of the investigation which he has conducted in connection with the Trinity House, and which he treats here under the title, "Researches on the Acoustic Transparency of the Atmosphere, in relation to the question of Fog-signalling." By this investigation, "not only have the practical objects of the inquiry been secured, but a crowd of scientific errors, which for more than a century and a half have surrounded this subject, have been removed, their place being now taken by the sure and certain truth of nature." In his preface Dr. Tyndall remarks on some of the criticisms which have been made on the results of the investigations referred to. It is interesting to learn that the work has been translated into Chinese, and published at the expense of the Government at the moderate price of 20*d.*

*Six Lectures on Light, delivered in America in* 1872-73. By John Tyndall, D.C.L., F.R.S., &c. Second Edition. (London: Longman and Co., 1875.)

WE are glad to see that these interesting popular lectures, to which we referred during and after their delivery, have reached a second edition; they are well calculated to interest the general reader, and, we have no doubt, have been the means of inducing many to make a systematic study of the subject to which they refer. The principal change in this edition is the omission of Dr. Young's "Reply to the Edinburgh Reviewers," the reprint of which in the first edition, Dr. Tyndall believes, has served the purpose intended. In place of this, a beautifully executed steel engraving of Lawrence's portrait of Young is prefixed to the volume.

*The Birds and Seasons of New England.* By Wilson Flagg. With Illustrations. (Boston: Osgood and Co. London: Trübner and Co., 1875).

MR. FLAGG is evidently an enthusiastic lover and close observer of nature in all her moods and phases, but this more from the sentimental and poetic than from the scientific point of view. His book consists of a great number of essays on various aspects of nature as manifested in the New England country, the most original being on the songs of the birds of that region. That he must be a very patient and very minute observer is evidenced by the fact that he has actually embodied in musical notation the songs of some of the principal singing birds of New England. We have no means of testing the correctness of Mr. Flagg's interpretation of these singers, but we should think, judging from the very careful observations he has evidently made, that they are generally correct. The work also contains essays on the aspects of nature in the various months of the year, and on such subjects as "The Haunts of Flowers," "Water Scenery," "The Field and the Garden," "Picturesque Animals," "The Flowerless Plants," "Swallows: their Hibernation," "Changes in the Habits of Birds," &c. Mr. Flagg's essays, we must say, are on the whole rather tedious, reminding us often of the tiresome moral essayists of last century, although they frequently contain passages of quite poetic beauty. There is also a sufficient amount of novelty about many of the subjects to add interest to his observations, and many facts are recorded concerning the habits of the New England birds that will give the book some value in the eyes of the naturalist. Those who love a quiet dreamy country life will find much throughout the book to interest them. Mr. Flagg, as we have said, evidently possesses the power of minute observation, and we would recommend him to bring himself abreast of the ornithology, and indeed general natural history, of the day, and carry on his observations from a more scientific point of view, which he can easily do, and still find scope enough for the satisfaction of his sentimentalism; he might thus render substantial service to science. Judging from what he says about the "hibernation" of swallows, he seems to be unaware that anything has been written on the subject of the migration of birds since the days of Gilbert White. Mr. Flagg's essays want the simplicity and naturalness and geniality of the Letters of that minute observer.

The illustrations of New England scenery are beautiful specimens of the heliotype process, and add much to the interest of the work. An index is appended containing both the common and the scientific names of the birds referred to in the work, but why should so carefully "got-up" a book have been printed without a table of contents?

*Practical Guide to Carlisle, Gilsland, Roman Wall, and Neighbourhood.* By Henry Irwin Jenkinson. Also, *Smaller Practical Guide.* By same author. (London: Edward Stanford, 1875).

MR. JENKINSON has succeeded in accomplishing what he has aimed at; he has written a really "useful, entertaining, and instructive" guide-book to the district indicated in the title. This district, of no very great extent, abounds in varied interest, and to those who desire to visit it we could recommend no more valuable companion than Mr. Jenkinson's "Practical Guide." He has evidently taken pains to make himself personally well acquainted with the localities he describes, and has diligently collected all the historical and other associations which add interest to the various points to be visited. To antiquaries, his "Walk along the Roman Wall from Coast to Coast" will be specially interesting, and with this book in one's hand we could imagine no more interesting and instructive walk for a summer holiday. The difference between the larger and smaller Guide is, that the former contains an additional eighty pages on the Local Names and the Natural History—Geology, Mineralogy, Botany, Entomology, and Ornithology—of the district, which adds to its value from a scientific point of view. Both books contain an excellent map of the county from coast to coast, embracing a distance of several miles on each side of the Roman Wall. We commend the Guide as the best to be had for the district to which it refers.

*North Staffordshire Naturalists' Field Club.* Annual Addresses, Papers, &c. With Illustrations. (Hanley: William Timmis, 1875.)

THIS club has now been in existence for ten years, and judging from the list of papers read and excursions made, has evidently carried out with creditable faithfulness the

object for which it was established—the study of the natural history and antiquities of the neighbourhood. The volume before us contains a selection of some of the principal papers read at the Club meetings during these ten years, and, as a whole, they reflect credit on the diligence, intelligence, and knowledge of the authors. Both the papers on general and those on local subjects contain much valuable material, quite deserving of publication, and the latter especially will be useful to those who want information on the natural history and antiquities of Staffordshire. One of the most interesting general papers is by Dr. J. Barnard Davis, "On the Interments of Primitive Man," which is illustrated by some beautifully executed woodcuts. Of the papers on local subjects, we may mention "Notes on the Fossil Trees in a Marl Pit at Hanley," by John Ward, F.G.S.; "The Geology of Mow Cop, Congleton Edge, and the surrounding district," by J. D. Sainter, F.G.S.; "On the absence of Waterfalls in the Scenery of North Staffordshire," by J. E. Davis; and "On the Organic Remains of the Coal Measures of North Staffordshire," by John Ward, F.G.S. Appended is a considerable list of Macro-Lepidoptera taken and observed in North Staffordshire by members of the Club, by T. W. Daltry, F.L.S. The illustrated paper on Croxden Abbey is a valuable one of its kind.

## *LETTERS TO THE EDITOR*

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*]

### The India Museum

IN your notice of the various transfers of the India Museum (vol. xii. p. 192), you do not allude to the somewhat important fact that from 1869 up to the recent opening of the new museum the whole of the Natural History Collections have been kept in closed boxes in the cellars of the India Office.* This has been a grievous wrong to working naturalists, who have constantly required access to typical specimens to solve various points of inquiry.

Again and again the attention of the authorities of the India Office was called to this state of affairs without effect, and naturalists cannot give too much credit to Lord Salisbury and the present Administration for putting an end to the scandal that existed so long.

Unfortunately, however, as I prophesied, it has been found on opening the boxes that some of them have been attacked by moth, and that valuable specimens have perished.

July 9 P. L. SCLATER

### Irish Cave Exploration

DURING the last few weeks Dr. Leith Adams, F.R.S., and myself have been exploring an ossiferous cave at Shandon, near here, under a grant from the Royal Irish Academy. Bones of mammoth, reindeer, bear, wolf, horse, and hare, were found in the *débris* of a quarry here in 1859, and are now in the Royal Museum, Dublin. We have worked through a considerable quantity of limestone breccia and stalagmite, in which and in a thin underlying deposit of cave-earth we have found numerous bones of the above-mentioned animals, indicating at least two individuals of mammoth, eighteen of reindeer, and five of horse, for which latter this is as yet the sole recorded locality in Ireland. The bones of bear show extreme age and signs of disease, and we have found the cast antler of a reindeer. Some of the bones have been gnawed, probably by wolves, and many have been broken by the falling-in of the roof of the cave. Though we have broken into a large chamber, we are as yet unable to form a clear conception of the original form of the cavern. A full account of the cave previous to the present exploration was given by Prof. Harkness in the *Geological Magazine* for June, 1870. G. S. BOULGER

Dungarvan, Co. Waterford, July 11

* See NATURE, vol. vii. p. 437.

### Sea-power

WILL you allow me to ask your readers one or two questions upon a subject which may ultimately belong rather to an engineering than to a purely scientific journal, but which at present has not, I believe, passed into the hands of practical men? I wish to know:

1. Where—if anywhere—use is made of the movements of the sea as motive powers?

2. Where I can find the latest and fullest information upon this subject?

I have an impression that a paper on the subject appeared in one of the volumes of NATURE, but I cannot find it. The latest paper on which I can now put my hand is M. Cazin's lecture on "Les Forces Motrices," in the *Revue des Cours Scientifiques* of Feb. 19, 1870. The lecturer mentions the failure of the *moulins de marée*, and gives a description, with diagram, of M. Tommasi's proposed *flux moteur*.

It has long appeared to me that the immense importance of the question as to the possibility of utilising sea-power has not been sufficiently recognised. The practical solution of this question would not only give to England an inexhaustible motive power, but would also, to a considerable extent, solve at once such problems as are connected with the rapid consumption of our coal, the pollution of our rivers in manufacturing districts, the unhealthy and immoral massing of our working classes in dirty and smoky towns and cities, &c. Moreover, the space covered by the sea-side factories would in many instances be merely the almost waste border-land between sea and field.

Giessen, June 30 A. R.

### Sea-Lions

IT will be no doubt interesting to your readers to learn that a pair of Sea-Lions have just been added to the collection of animals in the Jardin d'Acclimatation, Paris. They are said to have been brought from the North Pacific, and are marked *Otaria stelleri*, but I think from their small size and long narrow heads that the species is more probably *Otaria ursina*, the Northern Sea Bear, whose principal habitat is the Pribylov group. They are quite young, and the female is larger than the male.

The administrative committee of the Garden has caused a large tank to be built for their reception similar to that in our Zoological Gardens, only rather larger. They seem in excellent health, and it will be interesting to see whether they breed in captivity.

They have no special attendant, so far as I could see, as the Sea-Lions at our Gardens have, and are therefore only fed at stated times. On the day of my visit the keeper was late, and the female became hungry. She gave vent to her feelings by a curious cry, a prolonged "Ah—a—a—ah," repeated at short intervals—something like the bleating of an angry sheep.

It is to be regretted that these animals were not secured for our Gardens, where the best method of managing them is so thoroughly understood, and where consequently the experiment of breeding might have been tried with a better chance of success than elsewhere. J. W. CLARK

Museum of Zoology and Comparative Anatomy, Cambridge, July 11

### Hereditary Affection of a Cat for a Dog

I HAVE reared a fine mastiff. He is now three-and a-half years old. When quite a puppy he and a kitten evinced a strong liking for each other. The kitten, when able to leave her mother, fixed her residence in the dog's kennel, and never seemed happy when away from her large friend. She ate her breakfast out of the dog's bowl, and slept in his kennel with his paws around her. She used to catch mice and young rats, and carry them to him, and seemed quite pleased when he accepted friendship's offering. One morning I observed the cat preparing a bed with straw in the corner of the kennel—an ordinary wooden one, 4 feet by $2\frac{1}{2}$ feet. As she was going to have kittens, I thought she intended making the kennel her nursery, and "Cato" (the dog) her head nurse. Such proved to be the case. She brought forth five kittens, and there they lay for some time. The mother frequently went away for hours, leaving the dog to look after her family. I many times stooped down to examine them, and "Cato" stood by my side quite proud of his charge. The poor

cat came to an untimely end eighteen months ago, but the only surviving kitten of the five named above is as fond of the dog as her mother was. She brings mice, young rats, and rabbits, and lays them down before "Cato," and looks beseechingly till he takes them. She constantly plays with him and gets on her hind legs to look fondly into his face, while he puts his paws round her as he used to do to her mother.

She must have *inherited* this affection from her mother, as she was too young to have imitated her mother's actions at the time of her death. H. G.

Clent, July 13

### Scarcity of Birds

I SHOULD much like to know whether blackbirds and thrushes are scarce in other localities this year; because they have most unaccountably vanished from this neighbourhood, with the exception of a very few stragglers. Our cherries and strawberries are untouched. I have not observed a single blackbird or thrush in our garden or pleasure-grounds since the fruit ripened, though every other year we captured several in the cherry-nets, and shot many others.

R. M. BARRINGTON

Fassaroe Bray, co. Wicklow, July 12

## *OUR ASTRONOMICAL COLUMN*

VARIABLE STARS.—Of the three stars to which Col. Tennant draws attention as being probably variable ("Monthly Notices R.A.S.," June 1875), B.A.C. 740 appears more especially deserving of regular observation. The B.A.C. has adopted the magnitude assigned by Groombridge, 6; other estimates are:—Hevelius, 6; Fedorenko (Lalande, 1789 November), 8; Piazzi, 8, by seven observations; Schwerd, $8\frac{1}{2}$; Taylor, in 1834 or 1835, in vol. iii. of "Madras Observations," 7 (he calls the star 21 Cephei); Carrington, 8·1; the Radcliffe Catalogues, 7·5; and Durchmusterung, 8·4. With regard to the observation of Hevelius, which has been assumed to refer to this star, it may be remarked that the position given in his Catalogue for 1660, where it is No. 46 in Cepheus, does not well agree with the place of the Redhill Catalogue for B.A.C. 740, the difference of position amounting to 16′; nevertheless it is not easy to identify the star observed by Hevelius with any other in the modern catalogues. In the cases of the stars B.A.C. 4166 and 4193, also noticed by Col. Tennant, the estimates of magnitude from the epoch of Schwerd's observations to the present time appear pretty accordant. [In comparing the magnitudes assigned in different catalogues to the naked-eye stars it is necessary to bear in mind that in Argelander's Uranometria, and in Heis and Behrmann, 6·5, 5·4, &c., apply to stars which are judged to be somewhat brighter than an average sixth or fifth magnitude, and are not to be understood decimally, as is the case in the "Durchmusterung."]

THE DOUBLE-STAR Σ 1785.—The proper motion of this star is investigated in Argelander's researches, Bonn Observations, vol. 7. He remarks: "Die Begleiter geht mit," and of this there can be no doubt, since in the interval between Struve's first measures and the last published by the Baron Dembowski, the amount of proper motion, according to Argelander's values, would be $-20''\!\cdot\!9$ in R.A. and $-2''\!\cdot\!4$ in Decl. But the relative fixity of the components, which might have been surmised from Argelander's comparison of his differences of R.A. and Decl. for 1867·34, with those deduced from Struve's angle and distance in 1830, is clearly refuted by the recent measures. Thus we have—

| | | | | | |
|---|---|---|---|---|---|
| Struve ... ... | 1830·12 | Position | 164°·43 | Distance | 3″·487 |
| Dembowski ... | 1870·81 | ,, | 199°·60 | ,, | 2″·431 |

Perhaps it is not yet practicable to decide whether this relative change is due to slight difference of proper motion or to the binary character of the star, but it is evidently one that should be regularly measured. The position for the beginning of the present year is R.A. 13h. 43m. 24s., and N.P.D. 62° 23′·6.

THE TOTAL SOLAR ECLIPSE, 1927, June 29.—We believe the Rev. S. J. Johnson, of Upton Helions, Devon, was the first who pointed out the probable totality of this eclipse for a short interval in this country. It is one of those eclipses in which the moon's augmented semidiameter exceeds that of the sun by a small quantity, even where the sun is on the meridian. The following are approximate elements:—

Conjunction in R. A. 1927, June 28, at 18h. 27m. 14s. G.M.T.

| | ° | ′ | ″ | |
|---|---|---|---|---|
| R.A. ... ... ... ... ... ... ... | 97 | 6 | 12 | |
| Moon's hourly motion in R.A. ... ... | | 37 | 27 | |
| Sun's ,, ,, ... ... | | 2 | 36 | |
| Moon's declination ... ... ... ... ... | 24 | 4 | 35 | N. |
| Sun's ,, ... ... ... ... .. | 23 | 17 | 17 | N. |
| Moon's hourly motion in Decl. ... ... | | 1 | 18 | N. |
| Sun's ,, ,, ... ... | | 0 | 7 | S. |
| Moon's horizontal parallax ... ... ... | | 57 | 55 | |
| Sun's ,, ... ... ... | | 0 | 9 | |
| Moon's true semidiameter ... ... ... | | 15 | 47 | |
| Sun's ,, ... ... ... | | 15 | 44 | |

The sidereal time at Greenwich noon on June 29 is 6h. 26m. 17s., and the equation of time 3m. 3s. subtractive from mean time. The middle of general eclipse at 18h. 23m. 17s.

Hence the following points on the central line:—

| | ° ′ | | | ° ′ | | | ° |
|---|---|---|---|---|---|---|---|
| Long. | 3 21 | W. | Lat. | 54 11 | N. | Sun's zenith distance | 78·5 |
| ,, | 0 45 | W. | ,, | 55 40 | | ,, ,, ,, | 76·3 |
| ,, | 1 30 | E. | ,, | 57 3 | | ,, ,, ,, | 74·5 |
| ,, | 3 32 | E. | ,, | 58 15 | N. | ,, ,, ,, | 72·8 |

In 1° 37′ W. and 55° 12′ N. totality begins according to the above elements, June 28 at 17h. 19m. 31s. local mean time, and continues only nine seconds. It will be seen that the track of the central line in its passage over England is from Windermere, a little north of Morpeth, to the Northumberland Coast; it appears to just escape the Isle of Anglesey, but our data are not quite definitive.

MINOR PLANETS.—M. Stéphan has calculated elements of No. 146, discovered by M. Borrelly, from the Marseilles observations of June 9, 18, and 29, which give as a first approximation to the period of revolution, 1627 days; the planet has been named *Lucina*. Euphrosyne is in opposition about this time, with 57° South Declination; this body makes one of the widest excursions of any in the group, and may at times be found in Ursa Major. Daphne is the brightest of the small planets now near opposition.

## *SCIENCE IN GERMANY*

(*From a German Correspondent.*)

IN continuation of the last report (p. 152) we make the following further communication on Götte's "History of Development." As we have already mentioned, Götte deduces the structure of the embryo from the difference in size and position of the parts resulting from the division of the ovum. He supports this theory by the following observations. In the case of all ova, first of all a difference shows itself in the vertical axis, the parts round the upper pole being smaller and generating quicker than those round the under pole. The ratio of displacement is therefore also much greater in the upper hemisphere; and as this one expands concentrically it overgrows downwards the more bulky lower hemisphere, or causes it to bulge inwards, so that from the ovum which divides into many cell-like pieces, results a beaker-shaped

formation with double sides; *these are the two original germ-layers*. The space enclosed by the inner germ-layer is the intestinal cavity; the whole formation we call *gastrula* after Haeckel. As the causes of the formation of the two germ-layers are the same for all animals consisting of more than one cell (matazoa), according to Götte's view, the form of development of the gastrula is therefore common to all, however indiscernible it may often be in the outside appearance. The cause of this is partly that the above-mentioned difference between the upper and lower hemispheres of the ovum varies in magnitude. If this difference is small, the result will be that only a moderate part of the lower hemisphere will be pressed inward, the inner germ-layer remaining simple, as for instance with the lower polypi, which on the whole consist of two layers of cells. As the energy of the inward pressure increases, a third germ-layer, the so-called middle one, is split off the stronger inner one; this third one, from being a simple intermediary layer, may develop and originate many and important organs. If in the dividing ovum only the difference referred to in the vertical axis exist, the gastrula is naturally formed equally in all directions between the two poles, so that if further transformations take place, these likewise occur equally in all directions from the intestinal cavity and its principal axis, and therefore in radiated planes or lines. Thus the difference in the first axis of the ovum, if it acts by itself, always leads to a radiated structure of body which we find with Polypi, Medusæ, Echinoidea, and their relatives. Yet the higher developed representatives of these classes already show here and there, and in unimportant points, indications of a transition to a higher type. If we suppose the two horizontal axes of the ovum to be unequal, then the formation of the gastrula must naturally be unequal likewise. The inequality, which with many of the Vermes already shows itself during the first divisions of the ovum, causes the gastrula to extend in one direction more than in any other, and thus to receive another principal axis. If at the same time the two sides precede in development the other parts, two symmetrical masses are formed, situated opposite one another (germ-streaks), and which approach each other more or less on the stomach side, and there produce certain principal organs. To this transverse divisions may be added, as in the Arthropoda; or this may not occur, as in the Mollusca. Vertebrata finally do not show the preponderance of the first formation on two opposite symmetrical sides of the ovum, but only on one, where the odd germ-streak is situated and indicates the future back. In a manner similar to that of the typical foundation of the embryo, Götte tries to deduce all other phenomena of development not from hypothetical causes of inheritance, but directly from the laws of the formation of the ovum; as, for instance, the whole development of the different organs and tissues. Any essential change in a certain animal species must then be deduced from a change in the laws of formation, which are peculiar to the ovum, *i.e.* its first cause lies in the ovum, and the live animal can never transfer newly-gained changes of form directly to the law of formation of its germs, nor thus cause its descendants to inherit them.

## *NEW DISCOVERY IN CONNECTION WITH THE POTATO DISEASE*

THERE has been hitherto one "missing link" in our knowledge of the life-history of the potato-blight, *Peronospora infestans*. The non-sexual mode of reproduction by conidia or zoospores has long been known; but the sexual mode of reproduction has eluded observation. This link has now been supplied through the researches of Mr. Worthington Smith, who described his discovery in a paper read at the last meeting of the Scientific Committee of the Royal Horticultural Society, and published at length in the *Gardener's Chronicle* for July 10. He finds the female organs, the "resting-spores" or unfertilised "oospores," and the male organs or "antheridia," in the interior of the tissue of the tuber, stem, and leaf, when in a very advanced stage of decay; and he has actually observed the contact between the two organs in which the process of fecundation consists. In some remarks made at the meeting of the British Association last year by one of our high authorities, it was suggested that we have in the *Peronospora* an instance of the phenomenon not infrequent among fungi, known as "alternation of generations;" and that the germination of the true spores of the potato-blight must be looked for on some other plant than the potato. Mr. Worthington Smith has, however, looked nearer home, and has proved that the suggestion is not at all events verified in all cases. It is matter of congratulation that, after the lapse of a period of nearly thirty years since the publication of the first important memoir on the subject, this discovery—important alike from a scientific and a practical point of view—has fallen to one of our own countrymen, notwithstanding the foreign aid invoked by the Royal Agricultural Society in settling the still unsolved problems connected with this perplexing pest.

## *HISTORY OF THE PLAGIOGRAPH*

I SHOULD like to add a few words to my description of the instrument called the Plagiograph * (the *g* to be pronounced soft, like *j*, as in Genesis, Plagiarist, Oxygen) in NATURE, vol. xii. p. 168, for the purpose of explaining the order of ideas in which it took its rise, and also a very beautiful extension of another recent kinematical invention to which it naturally leads the way, and which, thus generalised, I propose to term the Quadruplane.

The true view of the theory of *linkages* † is to consider every link as carrying with it an indefinitely extended plane, and to look upon the question as one of relative ‡

* It may be questioned whether a new-born child can have a history. Perhaps it might have been more correct to have used for my title, "History of the Birth of the Plagiograph," but this would have been long; moreover, the Plagiograph proves to be an unusually precocious child, having in its very cradle given birth to a greater than itself, the Quadruplane, a full-grown invention described in the sequel of the text.

† It is quite conceivable that the whole universe may constitute one great linkage, *i.e.* a system of points bound to maintain invariable distances, certain of them from certain others, and that the law of gravitation and similar physical rules for reading off natural phenómena may be the consequences of this condition of things. If the Cosmic linkage is of the kind I have called complete, then determinism is the law of Nature; but, if there be more than one degree of liberty in the system, there will be room reserved for the play of free-will. We shoud thus revert to the Aristotelian view under a somewhat wider aspect of circular (the most perfect because the simplest form of motion) being the primary (however recondite) law of cosmical dynamics. Speaking of cosmical laws brings to my mind a reflection I have made upon the new chemical theory of atomicity. Suppose it should turn out that the doctrine of *Valence* should be confirmed by experience, and that the consequent logico-mathematical theory of colligation containing the necessary laws of consecution, or if cone pleases so to say of cause and effect should plant its foot and introduce a firm basis of predictive science into chemistry, how beautiful will be the analogy between this and the physical law of inertia! which really merely affirms the fact of each atom or point of matter carrying about with it a certain number, denoting its communicative and inverse receptive faculty of motion; for in such case Valency, also affirming a numerical capacity for colligation, will be the exact analogue in chemistry to Inertia in the theory of mass motion, and might properly assume the name of chemical inertia. Social individuals differ as egregiously as Isomers in their capacity for forming multifarious attachments.

‡ I believe it is to Mr. Samuel Roberts that we are indebted for the idea of passing from mere copulated links to planes associated with the links, and for the observation that the order of the corresponding Graphs is not thereby augmented. The substitution of the more general idea of linkage for link-work, and of isolating completely the conception of relative in lieu of absolute motion, is due to the author of these lines. Take the case of a Quadruplane in which the four joints in their natural order of sequence form a contra-parallelogram. It is well known (and the fact has been applied to machinery under the name of "the parallelogram of Reulleux") that the relative motion of an opposite pair of planes may be represented by causing two curves to roll upon each other; but I add that this may be done simultaneously for both pairs of planes, giving rise to a beautiful and previously unthought of double motion of rolling (without slip) between two ellipses for one pair and two hyperbolas for the other pair of planes. This is an immediate deduction from the conception of purely relative motion.

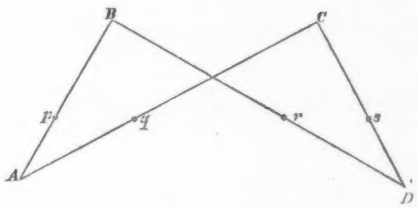
NOTE.—In the description of the plagiograph, for *pointed* parallelogram, p. 168, second column, line 14, lege *jointed* parallelogram. Also a dotted line should be drawn in Fig. 1 connecting the points O and P′.

motion which may be put under this form: When a *complete* linkage (meaning thereby a combination of jointed planes capable of only a definite series of relative movements) is set in motion, *what is the curve which any point in one of these planes will describe upon any other?*

In this mode of stating the question, the lines joining the pivots round which the planes can turn correspond to the jointed rods of the common theory. Fix any one of the planes, and the linkage becomes a link-work, or, to speak with more precision, a piece-work.

The curve described by a point in one plane upon any other plane has been termed by me with general acquiescence a Graph, and to keep the correlation closely in view, I have proposed to call the describing point the Gram.* We may further understand by canonigrams describing points taken in the lines connecting the joints and their corresponding curves, canonigraphs; Grams lying outside these lines and their appurtenant Graphs may be termed Epipedograms and Epipedographs; or, if these names are found too long for use, Planigrams and Planigraphs.

Now consider more particularly the generalised form of the linkage which corresponds to three-bar motion, of which Watt's parallel motion (so-called) offers a simple instance. If we were to revert to the old notion of link-work we should say that a three-bar motion is obtained by fixing one of the sides of a jointed quadrilateral of any form; but adhering to the more general conception of the matter here set forth, we may describe it as resulting from the fixation of any one of the planes of a quadriplane, *i.e.* a system of four planes connected together by four joints. Mr. A. B. Kempe, who has brought to light magnificent additions to Peaucellier's ever memorable discovery of an exact parallel motion in a paper which I have had the pleasure of presenting to the Royal Society of London, in the course of conversation with me made the very acute and interesting remark that in an ordinary 3-bar motion, supposing the distance between the two fixed centres to be given, and the lengths of the two radial arms and the connecting rod to be also given, the order in which these three latter elements are arranged will not affect the nature of the canonigraphs described. Whichever of the three lengths is adopted as the length of the connector and the remaining two as the lengths of the radial arms, the very same system of curves will be described in all three cases so far as regards their form: every canonigram in the arrangement will have a canonigram corresponding to it in each of the other arrangements such that the corresponding curves described will be similar and similarly placed—a most remarkable, and, for the purposes of theory, an exceedingly important observation; but, as Prof. Cayley observed, when once stated, a self-evident deduction from the principle of the ordinary pantigraph.† It therefore occurred to me that a corresponding theorem ought to hold for all graphs whatever—for plagiographs just as well as for canonigraphs; and by a very simple application of the general double-algebra method of *Versors*, I found that this would be the case, the only difference being that now the corresponding graphs, instead of being similar and similarly situated, would be similar but not similarly situated; in other words, that the lines joining the centre of similitude with the corresponding points, instead of coinciding in direction, would make for each particular graph a constant angle with each other. Thus I passed from the conception of the common Pantigraph to that of the Quergraph, or Plagiograph, or Skew Pantigraph, as the new instrument described in the previous article may indifferently be called. I now come to the second part of my story, and proceed to explain the remarkable extension a theorem analogous to and naturally suggested by the




Plagiograph gives of Mr. Hart's remarkable discovery of a *cell* consisting of only four jointed rods which possesses the same property of reciprocation as Peaucellier's six-sided cell.

This cell is exhibited in the figure above. The four jointed rods A B, A C, C D, B D are equal in pairs, A B and C D being equal, also A C and B D. In fact, the figure is nothing else but a jointed parallelogram twisted out of its position of combined parallelisms, and may be termed a contra-parallelogram. When the cell is in any position whatever, imagine a geometrical line to be drawn parallel to the lines joining A and D or B and C (for these lines will obviously always remain parallel to each other), cutting the four links in the points $p, q, r, s$.

Now take up the cell and manipulate it in any manner you please so as to change its form, the same four points $p, q, r, s$ will always remain in the same straight line, the distances $pq$ and $rs$ will always remain equal to one another, and the product of $pq$ by $pr$, or, which is the same thing, of $sr$ by $sq$, will never vary, so that $pr$ remains (so to say) a constant inverse of $pq$, and $sr$ of $sq$—the actual value of the constant product (called the modulus of the cell) being the difference between the squares of the unequal sides of the contra-parallelogram, multiplied by the product of the segments into which any one of the links is separated by the points $p, q, r$, or $s$, and divided by the square of such link. Now Mr. Kempe and myself—he by the free play of his vivacious geometrical imagination, I by the sure and fatal march of algebraical analysis—have arrived at the following beautiful generalisation of Mr. Hart's discovery. On A B, B D, D C, C A describe a chain of four similar triangles, the angles of which are arbitrary, but looking towards the same parts, and so placed that the equal angles in any two contiguous triangles are adjacent—call the vertices of these triangles P, Q, R, S (which will be in fact the analogues of the points $p, q, r, s$ before mentioned): then it will be found that the figure P Q R S will be a parallelogram whose angles are invariable, and the product of whose unequal sides is constant; in a word, a

* Gram is intended to suggest the notion of a *letter* discharging the duty of a point. In inventing new verbal tools of mathematical thought, the following are the rules which I bear in mind:—1. The word must be transferable into the common currency of the mathematical centres of Europe, France, Germany, and Italy. 2. It must enter readily into combinations and be susceptible of inflexion fore and aft. 3. It should contain some suggestion of the function of the idea intended to be conveyed. 4. It should by similarity in quality or weight of sound conjure up association with the allied ideas. 5. When all these conditions are incapable of being simultaneously fulfilled, they should be observed as far as possible, and their relative importance estimated according to the order in which they are written above.

† Suppose A B, B C, C D to be three jointed rods fixed at A and D. Choose either of the fixed points, say A, and complete the parallelogram A B C B′ A, regarding C B′, B′ A as two additional jointed rods; through A draw any transversal, cutting the two indefinite straight lines A B, B B′ in P and P′ respectively; then whatever curve P describes when the system is set in motion, P′ by the principle of the common Pantigraph will describe a curve similar and similarly situated thereto, A being the centre of similitude. Now, it will be noticed that A B′ C D is a system of four jointed rods in which the lengths A B′, B′ C are the same as the lengths A B, B C in inverted order, viz., A B′ = B C, and B′ C = A B, and as we may proceed from the point D equally well as from A, it follows that all the six interchanges may be rung between the three lengths A B, B C, C D. This is the proof of Mr. Kempe's admirable theorem; but does the simplicity of the principle involved take away in any degree from the beauty of the result, or rather, is not the interest of the conclusion enhanced by the simplicity of the means by which it is arrived at? In fact, as Kant has observed, the groundwork of all mathematical proof consists in putting things together by a free act of the imagination; and the essence of Euclid is to be sought in the constructions which antecede the formal proofs. The real proof is the construction, and no one has the right to call Mr. Kempe's discovery "a truism."

parallelogram of constant area and constant obliquity.*

The modulus, or constant product of the sides, follows the same rule as in the special case, except that for the product of the segment of a link divided by the square of its entire length, must be substituted the product of the sines of the angles adjacent to any link divided by the square of the sine of the angle subtended by it.

Just as in the first case $pq.pr$ and $sr.sq$ are constant, so now PQ.PR and SR.SQ are constant; but whereas $pq$ coincided in direction with $pr$ and $sr$ with $sq$, PQ and PR, like SR and SQ, remain inclined to each other at a constant angle; in a word, as the Plagiograph is to the Pantigraph, so is the Sylvester-Kempe Inverter or Reciprocator to Mr. Hart's.† Do not let it be supposed that this new reciprocator is to be consigned to the limbo of barren mathematical generalities—very far from it; it is very likely indeed to find a most valuable application to mechanical practice, and to subserve the purposes of that immediate "Utilitarianism"‡ so dear to the Philistine mind; for, as by means of Mr. Hart's Quadrilateral, when one of the four named points, say $p$, is absolutely fixed, and one of its non-conjugate points, say $r$, is attached to the end of a radius so centred and of such a length that the path of $r$ is a circle which, *geometrically* completed, would pass through $p$, the remaining conjugate point $q$ will be forced to describe a straight line perpendicular to the line joining the two fixed points—so by means of our Quadruplane, when P is fixed and R made to move in the arc of a circle passing through P, the point Q may be made to describe a straight line having any *desired obliquity* to the line of centres, the amount of such obliquity depending on the magnitude of the supplemental equal angles P, Q, R, S. Thus the Plagiograph (and in the first instance Mr. Kempe's notice of the homœographic commutability of the lengths of the connecting rod and the radial bars in ordinary three-bar motion) has led by a devious path to the construction of a three-piece-work giving the most general and available solution of the problem of exact parallel motion that has been discovered or that can exist—I say the most available, for it is evident, in general, that piece-work must possess the advantage of greater firmness and steadiness from the more equal distribution of its strains over ordinary link-work.

The Peaucellier and Hart cells, duly mounted, afford the means by obvious methods of adjustment to cut straight lines at any distance from either of the fixed centres, but confined to lying perpendicular to the line of centres; whereas the Quadruplane puts it into our power with one and the same instrument affected with simple means of adjustment to make straight cuts (and, if desired, two parallel ones simultaneously) in all directions as well as at all distances in the plane of motion. So again the Plagiograph enables us to apply the principle of angular repetition (as, for instance, in making an ellipse with dimensions either fixed or varying at will, successively turn its axis to all points of the compass) to produce designs of complicated and captivating symmetry from any simple pattern or natural form, such as a flower or sprig; and as the head of a house at Oxford in the good old port-wine days was heard to complain about the electro-magnetic machine, that "he feared it would place a new weapon in the hands of the incendiary" (the power of Swing being then rampant in the land), so, but with better reason and upon the highest authority, it may be predicted that this simple invention will be found to place a new and powerful experimentative and executory implement in the hand of the engine-turner, the pattern-designer, and the architectural decorator.

J. J. SYLVESTER

Athenæum Club, and 60, Maddox Street, W.
July 5.

P.S.—I rejoice to be able to state that the Institute of France has quite recently adjudged its great mechanical prize, the "Prix Montyon," to Col. Peaucellier for his discovery of an exact parallel motion when a lieutenant in 1864. The first practical application of this discovery, made by Mr. Prim under the sanction of Dr. Percy, may be seen daily at work in the Ventilating Department of our Houses of Parliament. The workmen there, who never tire of admiring its graceful and silent action, have given it the pet name of the "Octopus," from some fancied resemblance between its backward and forward motion and that of the above-named distinguished Cephalopod. I feel a strong persuasion that when the inertia of our operative classes shall have been overcome, this application will prove to be but the signal, the first stroke of the tocsin, of an entire revolution to be wrought in every branch of construction; and that machinery is destined eventually to merge into a branch of the science of Linkage in the sense in which that word is used in the text above.

* I early noticed the analogy between M. Peaucellier's six-linked reciprocator and the primitive form of the pantigraphic proportionator formed by two parallelograms having an angle and the directions of its two containing sides in common, also therefore consisting of six links; and indeed pointed out that, starting (to fix the ideas) from a negative Peaucellier-cell (such as is in successful use in the Houses of Parliament for ventilating the brains of our representative and hereditary legislators), we have only to unfix the two interior links from the angles to which they are attached, and attach them instead to two sides of the containing lozenge, so as to be parallel to the other two sides; and we pass from a Reciprocator to the comparatively barren Proportionator. Now as a Proportionator (the Pantigraph in common use) exists with only four sides, it ought to have been inferred as fairly probable that a Reciprocator also might be discovered having only four sides, *i.e.* by analogy, the probable existence might have been inferred of a Hart cell—the contra-parallelogram first imagined by Mr. Samuel Roberts, but rediscovered and hugged with the affection of a supposed original discoverer, and warmed into new and unsuspected uses by its foster-parent Mr. Hart. I shall have no difficulty in finding a generalisation of the Peaucellier-cell standing to it in the same relation as the Quadruplane does to the Hart-cell, and similarly for the Proportionator, so that we shall have the fourfold proportion—Peaucellier-cell : Hart-cell : Quadruplane : New Peaucellier cell : : Old Pantigraph : Common Pantigraph : Plagiograph : Oblique Old Pantigraph; but, except as completing a chain of analogies, the last terms in each quatrain will probably not prove of any practical importance.

† In the case of a 3-piece motion whose fundamental linkage (*i.e.* the quadrilateral formed by the lines joining the pivots and the fixed points in their natural order of succession) is subject to the condition that either the two pairs of opposite sides or two pairs of contiguous sides are equal for each pair, the Planigraph (leaving out of account its circular portion) is the inverse of a conic. In the first case (that of the contra-parallelogram) the position of this node is seen immediately to be the opposite to the Planigram in respect to the centre of the figure in its untwisted (*i.e.* parallelogrammatic) form. In the second case, that of the so-called kite-form, it was found to be far from easy to determine its position. Even our Cayley did not quite succeed in determining it from the analytical equations, and it was reserved for M. Manheim to deduce it geometrically by a most elegant but very elaborate construction given in a paper inserted in the Proceedings of the Mathematical Society of London. By the aid of the reciprocity established by me above we pass at once from the case of the contra-parallelogram to that of the kite-form, and the problem literally solves itself as easily as a musical passage can be transposed from one key to another. It is to that profound mathematician, Mr. Samuel Roberts, that we are indebted for bringing to light these two cases of 3-bar motion, in which the general 3-bar sextic Graph breaks up into a circle, and the inside of a conic, and I have proved that no other such cases exist. Mr. Roberts's papers are inserted in the Proceedings of the London Mathematical Society, which is indebted for its existence, at least in its present form (being originally little more than a juvenile mathematical debating society among the students of University College), to the organising talents of Mr. Hirst, who has reason to be proud of his progeny. Similar societies on a precisely similar basis, and adopting the rules of its elder sister, have been subsequently founded in Paris, Warsaw, and, I believe, other capitals in Europe, and, it is safe to predict, are destined to play no unimportant part in the further evolution of our time-honoured yet ever young, ever fresh, and self-renovating science—Othello, Hamlet, and Romeo all in one. Meanwhile, in the University supposed to be peculiarly dedicated to the advance of mathematical science, a young and very promising mathematician (whose name shall not be divulged) *àpropos* of a movement kindly attempted, without my being previously consulted, to place me in a position where, in the vicinity of our central luminary, I might have been in my proper place, and helped to reflect some portion of his rays upon surrounding bodies, wrote to me lately: "You cannot imagine the bitter prejudice that prevails here against pure mathematics, &c." I freely forgive those, "the bigots of a narrow creed," who entertain such sentiments, knowing that "they know not what they do."

‡ What would our English statesmen say to the conduct of the proverbially parsimonious Prussian Government and the nineteenth century Richelieu, "dertolle Bismark" in appropriating a million and a half of marks (75,000*l*. sterling) placed at the free disposal of the modern Aristotle, Helmholtz, for constructing the bare shell alone of the new Physical Laboratory at Berlin! If such an appropriation were proposed at home, would there not run through the land a frantic shriek or muttered low of disapprobation at such a wanton waste of the public funds on mere speculative science?

## CHARCOAL VACUA*

(*From a Correspondent.*)

PROF. DEWAR began his discourse by describing the different processes which have been adopted for obtaining very perfect vacua, and referred to a paper regarding this matter, read by Prof. Tait and himself before the Society last year.

By the ordinary air-pump the exhaustion can only be obtained to $\frac{1}{8}$ of an inch, *i.e.* $\frac{1}{240}$ of the ordinary pressure.

Regnault, in some of his experiments, after exhausting with the air-pump, boiled water, and when the water had evaporated, sealed the vessel, and then broke a flask inside containing sulphuric acid, and so the water vapour was absorbed.

Dr. Andrews' way is a revival of one due to Davy, viz. to fill and exhaust twice with carbonic acid after the pump exhaustion, and then by caustic potash to fix the $CO_2$ which is left.

Professors Tait and Dewar's method is to take advantage of the power charcoal has of condensing gases; while the exhaustion, by means of a mercury pump, is going on, the charcoal is kept heated; when the exhaustion has been carried as far as possible, the vessel is sealed, and as the charcoal cools, it condenses the very small residue of gas there may be present, and this can again be temporarily driven out by heating the charcoal. The test they have employed to gauge the perfection of their vacuum has been to see if it will allow an electric spark to pass. It is well known that at the ordinary atmospheric density it requires considerable tension for a spark to pass through air, and as the density diminishes, the spark passes more easily; but when a certain point is reached the difficulty again increases, and in a very perfect vacuum no spark passes at all. Two wires, $\frac{1}{4}$ inch apart, in one of Tait and Dewar's exhausted tubes would not allow a spark to pass, although a powerful coil was employed.

Prof. Dewar went on to say that the effect of light and heat had been tried by many experimenters, on magnets and delicately suspended bodies, and in the *Edinburgh New Philosophical Journal* for 1828 there is an interesting account of some experiments performed by Mark Watt on the same subject, with apparatus little differing in appearance from that now used by Mr. Crookes.

Recently Mr. Crookes has found some curious results which he seems to think are inexplicable. He found that the action of a beam of light on a delicately suspended glass fibre with a disc at each end was repulsion of the disc when the exhaustion was perfect, but attraction when at ordinary pressures. The discs were light bodies of pith or cork. One side of each was covered with lampblack, the other was white. The first thing to be noticed is that the blackened face is affected much sooner than the white face. Since there was attraction at one density and repulsion at another, it follows that at some intermediate density there is no action at all, and this neutral point depends among other things on the conductivity of the body and the nature of the residual gas.

It will be seen that for delicate action one essential is that the glass of the vessel be thin. The sensibility is also found to increase with the perfection of the vacuum.

The first fact ascertained is that the action follows the law of the inverse square of the distance, that which all radiation obeys. Thus, when the light was $3\frac{3}{4}$ inches from the beam, the reading was 110, zero 22, deflection 88; at $7\frac{1}{2}$, reading 48, deflection 22, or only about $\frac{1}{4}$; and when at $11\frac{1}{2}$, reading 33; and as zero changed, reading 33, deflection 9, or only about $\frac{1}{9}$.

The next experiment was this. Professor Dewar interposed between the candle and the beam a substance opaque to heat rays. The candle was placed so as to give a large deflection, and then a vessel of ordinary glass was interposed, and the deflection decreased, and on filling the vessel with water, which is almost opaque to heat rays, there was no perceptible deflection left. This shows that when the heat rays are absorbed or prevented from reaching the disc, hardly any action takes place. A layer of water $\frac{1}{4}$ of an inch thick diminishes the amount of deflection to $\frac{1}{8}$ part of the original.

Next a smoked piece of rock-salt was interposed, or a vessel filled with a substance transparent to heat but opaque to light, viz., a solution of iodine in bisulphide of carbon. The deflection was as before, large; on the empty screen being interposed a diminution followed, due to the non-transparency of the glass screen for heat. But when by means of the iodine solution the light rays were cut off there was hardly any further diminution in the deflection. This shows that the light rays may be taken away without any considerable diminution of the action.

Prof. Dewar then proceeded to show that the heating of the disc was the efficient cause of the action.

Two equal discs, one of rock-salt, the other of glass, were attached to the glass fibre. The rock-salt was inactive when the beam was thrown on it; the glass disc was active. The reason is evidently that the rock-salt is not heated, being transparent to heat, whereas the glass is opaque, absorbs the heat and is heated. Unless the shell of the receiver be thin, however, the selective action is very small, as the glass envelope absorbs much of the heat.

The back of the rock-salt disc was then coated with lampblack, and the beam sent through to the blackened side. Yet there would be attraction. The heat and light passes through the rock-salt and is absorbed by the lampblack at the surface of contact. The lampblack is heated up in consequence, but it is so bad a conductor that before this heat can be conducted through the thin coating of lampblack it is conducted through the rock-salt, heats it up, and the action is repulsion. If the lampblack were not so bad a conductor, all the lampblack would be first heated up and there would be repulsion at the other side, or apparent attraction. The subsequent action is due to the giving out heat unequally on the two sides.

The next modification was to substitute for the rock-salt clear sulphur and ordinary sulphur on the other. The peculiarity of clear sulphur is that when acted on by light it resumes the appearance of ordinary sulphur, with a disengagement of heat. A beam was thrown on this, and the effect was, as expected, attraction, the back being heated, and repulsion, there being attraction on the other side. The success of this experiment depends on the way in which the sulphur is transforming.

This suggested to the learned Professors an instrument for detecting the presence of very high violet rays. Have the transparent discs coated with white phosphorus, which is opaque to the ultra-violet rays. There would ensue a chemical action with disengagement of heat, and the result would be a motion of the discs. To show the sensitiveness of the apparatus, it may be stated that an ordinary lucifer-match held at a distance of 4 feet produced instant action, which was observed by means of a telescope. When ether was brought near there was attraction. The disc followed the ether about because there was radiation of heat from the disc. The action is clearly due to the infinitesimal heating of the discs. Reynolds suggested the action was due to the evaporation of some fluid on the surface of the discs. The recoil of the evaporating particles leaving the disc sent it back.

When the action takes place in ordinary pressures it is probably due to convection currents. The air in front of the disc is heated and ascends, there is a vacuum, and hence the disc advances. To understand the action that takes place when the exhaustion is more perfect, we must consider how much gas there is in the vessel. The capacity

* By Professors Tait and Dewar. Paper read by Prof. Dewar before the R.S. of Edinburgh on Monday, July 12.

of the vessel is about a litre or 1000 cubic centimetres. But since we know that the exhaustion has reduced the density to $\frac{1}{4000000}$ of its original, the volume occupied by the residual gas at ordinary pressures would be that of a little bubble $\frac{1}{100}$ of an inch in diameter.

Sir Wm. Thomson, T. Clerk-Maxwell, and Clausius have shown that in a gas, at ordinary pressure, the mean or average path between two collisions is about $\frac{1}{10000}$ of a millimetre. When the pressure is reduced to $\frac{1}{4000000}$ the mean will be 400 millimetres, or about a foot and a half. What takes place is this. The particles of the gas are flying about in all directions, with a velocity which depends on the temperature. When they impinge on the heated disc their velocity is increased, they go off with a greater velocity than those which go off from the colder side, and hence there is a recoil of the disc. When the gas is at all dense the particles get a very short way before they are met by another and sent back, and so the velocity gets a common velocity before any visible action takes place. When the gas is rare the particles may get a long way off before they meet others, and so the action becomes perceptible.

In case of cooling they go away with diminished velocity and a negative recoil.

The author of the paper went on to show that the total mechanical action on a square centimetre of black surface derived from the radiation of a magnesium lamp, at a distance of 150 mill., did not exceed a continuous pressure of $\frac{1}{10}$ part of a milligramme, and that the total work done did not amount to the five-millionth part of the available energy received by the movable surfaces.

## *ADDITION TO OUR KNOWLEDGE OF THE TERMITES**

FRITZ MÜLLER has recently published a short but interesting memoir on the larvæ of Calotermes, a genus of Termites, which he describes with his wonted care and accuracy. We cannot, of course, here follow him in detail; but, as is so often the case in the writings of this eminent naturalist, he draws our attention by his descriptions to several points of unusual interest. As occurs in some other insects, the youngest larvæ of Calotermes differ much in form from those somewhat more advanced in age. The form of the younger larvæ may be accounted for on two hypotheses. It may be an adaptation to the mode of life, or it may be the original larval form of the group. In the latter case, Herr Müller considers that it would be an extremely interesting form, because, in his opinion, Calotermes is one of the oldest, if not the oldest, of existing insect genera; since, according to Hagen, the carboniferous Termites described by Goldenburg from the cold strata belong to this group. Under the latter hypothesis, therefore, the younger larvæ of Calotermes would have, as regards insects, an interest similar to that possessed by Nauplius among Crustacea; and, according to Müller, the latter really is the case. The youngest larvæ of Calotermes live with their elder sisters, in the same localities, on the same food, and, in fact, under precisely the same conditions. These older larvæ have, in a word, completely adapted themselves to their dwelling-place and mode of life. Like most animals which burrow in earth, wood, or stone, they are cylindrical in form. Not so the youngest larvæ, which are flattened, and have the thorax laterally expanded. Their structure is, in Müller's opinion, as unsuitable as possible for animals inhabiting wood. This form is therefore probably only possessed through inheritance from far distant ancestors.

It is unnecessary to point out how great is the interest attaching to these larvæ, if Müller's view be correct; nor would I venture to express any dissent from his conclusions. But, I confess, there seems to me a difficulty in comprehending why the younger larvæ have not adapted themselves to their conditions, in like manner as their elders.

May there not possibly be some circumstances which have hitherto escaped observation, and which might render the form of these larvæ not so altogether unsuitable as Müller supposes?

I will just refer to one other point in this interesting paper. The author shows that the main, if not the whole growth of the antenna takes place in the third segment: the two basal ones and the terminal portion remaining almost unaltered. My husband, many years ago (Linn. Trans., 1863), showed this to be the case in the Ephemera (*Chloeön*), and it would be interesting to know whether the same thing occurs among other Neuroptera.

High Elms ELLEN LUBBOCK

* By Fritz Müller.

## *NOTES*

THE Loan Exhibition of Scientific Apparatus at South Kensington, to which we have already referred (vol. xi. p. 301), will open on the 1st of April, 1876, and remain open until the end of September, after which time the objects will be returned to the owners. It will, as we have already intimated, consist of instruments and apparatus employed for research, and other scientific purposes, and for teaching. It will also include apparatus illustrative of the progress of science, and its application to the arts, as well as such as may possess special interest on account of the persons by whom, or the investigations in which, it had been employed. The precise limits are detailed under several sections in a syllabus which has been issued for the information of exhibitors. Models, drawings, or photographs will also be admissible where the originals cannot be sent. The apparatus may, in certain cases, be arranged in train as used for typical investigations; and arrangements will be made, as far as it may be found practicable, for systematically explaining and illustrating the use of the apparatus in the various sections. Forms on which to enter descriptions of objects offered for exhibition may be obtained on application to the Director of the South Kensington Museum, London, S.W. These forms should be filled up and returned as soon as possible, so that exhibitors may receive early intimation as to the admissibility of the objects they propose to send. The cost of carriage of all objects selected for exhibition will be defrayed by the Science and Art Department. It is hoped that institutions or individuals having instruments of historic interest will be good enough to lend them. The following are the various sections into which the Exhibition will be divided:—Arithmetic, Geometry, Measurement, Kinematics, Statics and Dynamics, Molecular Physics, Sound, Light, Heat, Magnetism, Electricity, Astronomy, Applied Mechanics—[as the Exhibition must be regarded as chiefly referring to education, research, and other scientific purposes, it must in this division consist principally of models, diagrams, mechanical drawings, and small machines, illustrative of the principles and progress of mechanical science, and of the application of mechanics to the arts],—Chemistry Meteorology, Geography, Geology and Mining, Mineralogy, Crystallography, and Biology.

MR. SULLIVAN on Tuesday, in the House of Commons, moved with regard to the necessity for having a Museum of Science and Art in Dublin. He, as well as the other speakers, seems to be ignorant of the fact that in addition to its educational staff and appliances, the Royal College of Science in Dublin possesses the germ of an admirable museum which formerly constituted the Museum of Irish Industry. It seems probable that what is needed is a removal of the specimens from the College to a suitable building; probably an enlargement of the Royal Dublin Society would be best, and the space thus gained in the College of cience

would be invaluable for laboratories. Few of the outside public are aware what a fine collection of mechanical apparatus the late Professor of Mathematics, Dr. Ball, made in the College, and how highly desirable it is that these should be turned to active and good use by his successor.

THE Royal Commission on Scientific Instruction and the Advancement of Science have held their final sitting and appended their signatures to the Sixth Report on Science Teaching in Public and Endowed Schools; the Seventh Report on the Universities of London, Scotland, Dublin, and the Queen's University in Ireland; and the Eighth and Final Report on the Advancement of Science and the relations of Government to that branch of study.

FOR the Paris International Geographical Exhibition an immense number of photographs have been received from the Palestine Exploration Fund, which will afford a good idea of the work done by British explorers. The Russian and Austro-Hungarian Governments have erected, each at its own expense, an elegantly fitted pavilion on the terrace *du bord de l'Eau*, where their exhibits will find ample room. M. Esler, the Danish delegate, has brought with him a complete collection of the dresses used by the natives of Greenland. All the original maps of Paris, from the celebrated tapestry carpet up to the latest published by M. Haussmann, will be exhibited by the French Government. A special section has been arranged for alimentary preparations useful for travelling purposes, and another for inventions relating to salvage.

SESSION 1875-6 of the Teachers' Classes of St. Thomas Charterhouse School of Science will commence on Sept. 25 next. A public meeting will be held on some Saturday early in October, when an address will be delivered by Dr. Carpenter. The managers of the Gilchrist Trust have made a grant for the delivery of a course of lectures, on alternate Friday evenings, during the session. The arrangements are in the hands of Dr. Carpenter, secretary to the Trust, who is in active communication with Professors Huxley and Tyndall and other eminent lecturers. The lectures will be delivered in the Foresters' Hall, Wilderness Row, near the Charterhouse Schools.

THE Committee of the French Association for the Advancement of Science, which meets at Nantes on August 19, have issued invitations and a list of some of the French men of science expected to be present. Among the subjects which will be brought before the Association are Researches on Prussic Acid, by M. Claude Bernard; an important paper by M. Pasteur on Beer; an account of the work relating to the Meridian of France, by Commandant Perrier; and a new rhinoplastic process, by Dr. Ollier. Among those expected to be present are, MM. Dumas, Claude Bernard, Pasteur, H. St. Claire Deville, De Quatrefages, Levasseur, P. Broca, E. Caventou, L. Lefort, E. Moreau, Trélau, Verneuil, and other eminent scientific Frenchmen.

AT the half-yearly general meeting of the Scottish Meteorological Society on Tuesday last two interesting papers were read; one on "The Mortality of the Large Towns of the British Islands in relation to Weather," by Mr. Buchan; and the other on "Weather and Epidemics of Scarlet Fever in London during the past thirty-five years," by Dr. Arthur Mitchell. We hope to be able to give a notice of these papers in our next number.

ON the 7th of July an extraordinary hail and thunder storm raged over a large part of France, many towns having been deluged in succession. At Geneva, where the phenomenon was more satisfactorily observed than elsewhere, it was found that the hailstones fell on a belt at first only four kilometres in breadth, but enlarging, when near the lake, to about thrice that breadth. The path of these thunderstorms will be investigated by the Meteorological Boards of the different departments, but it will take some time before they are correctly mapped. M. Dumas, at Monday's sitting of the Paris Academy, read a letter from M. Calladon, of Geneva, stating that hailstones of 300 grammes each had been collected; and a letter from M. W. de Fonvielle, describing the icicles observed by M. Duruof on his balloon in his last ascent, about ten days ago. M. Dumas directed the attention of the Academy to the importance of that observation, in order to explain how gigantic hailstones can be generated during abnormal atmospheric perturbations.

THERE is nothing particularly noteworthy in the Report presented by the Radcliffe Observer to the Board of Trustees on June 29. The work of the Observatory has been steadily pursued, interrupted only by an unusual amount of unfavourable weather. A great advance has been made in the reduction and printing of the observations during the past year.

A LIVELY interest in science seems to have been awakened in Aberdeen, by means of lectures on anatomy and physiology, delivered gratuitously by Prof. Struthers on Saturday evenings in Marischal College. They have been very largely attended by both sexes, and particularly by that portion of the community, comprising all classes, whose opportunities for instruction in scientific subjects have been necessarily restricted. A beautifully illuminated and handsomely mounted address was recently presented to Dr. Struthers by the Dean of Guild of the city on behalf of a large number of subscribers, as a mark of their appreciation of his disinterested labours. The Aberdeen School Board had been stimulated to resolve to introduce some physical science into the Grammar School. They propose to have a course of Elementary Chemistry and Elementary Physics, and also one of Botany. The Mechanics' Institution of Aberdeen, now aided by a munificent bequest from the late Dr. Neil Arnot, himself an Aberdonian, is also doing valuable work in the way of disseminating systematic knowledge in various branches of physical science.

THE Halifax Geologists' Field Club now consists of ninety members, and during the past year many papers have been read and a considerable number of excursions made. The president, Mr. J. W. Davis, in his address on May 19, gave an interesting sketch of the work done at the Settle Caves. Mr. L. C. Miall gave a lecture on the 2nd June on the Construction of Geological Maps; and on the 16th, Prof. A. H. Green lectured on the General Structure of the Central Part of Yorkshire Coal Field. The Club seems to be in a healthy condition.

WE are glad to see from the "Reports and Proceedings" for 1874 and part of 1875 of the Miners' Association of Cornwall and Devon, which carries on its work to some extent in connection with the Science and Art Department, that notwithstanding the present great depression in mining, this exceedingly useful Association has been able to continue its good work among the class for whose benefit it has been founded. The report of the lecturer, Mr. B. Kitto, F.G.S., is very satisfactory, and is followed by a number of valuable papers on various subjects connected with mining.

THE *Revue Scientifique* for July 10 contains M. J. Bertrand's valuable account of the life and work of the late M. Elie de Beaumont, recently read before the Paris Academy of Sciences.

PRINCIPAL DAWSON has sent us an interesting paper, being the Presidential Address to the Natural History Society of Montreal for 1875, entitled "Recollections of Sir Charles Lyell," containing among other things some personal reminiscences of the great geologist's visits to America.

THE "Proceedings of the American Academy of Arts and Sciences" for 1874-5 are just to hand; the following is a list of the papers contained in the volume:—Researches on the Hexatomic Compounds of Cobalt, by Wolcott Gibbs, M.D. Contributions to the Botany of North America, by Asa Gray. Graphical Integration, by Edward C. Pickering. On the Solar Motion in Space, by Truman Henry Safford. Historical Sketch of the Generic Names proposed for Butterflies: a contribution to Systematic Nomenclature, by Samuel H. Scudder. On the wide diffusion of Vanadium and its association with Phosphorus in many Rocks, by A. A. Hayes, M.D. Foci of Lenses placed obliquely, by Prof. E. C. Pickering and Dr. Chas. H. Williams. On the Effect of Heat upon the Magnetic Susceptibility of Soft Iron, by H. Amory and F. Minot. A Conspectus of the North American Hydrophyllaceæ, by Asa Gray. Revision of the Genus Ceanothus, and Descriptions of New Plants, with a Synopsis of the Western Species of Silene, by Sereno Watson. List of the Marine Algæ of the United States, with Notes of New and Imperfectly Known Species, by W. G. Farlow. On a New Induction Coil, by John Trowbridge. On the Effect of Armatures on the Magnetic State of Electro-Magnets, by B. O. Peirce and E. B. Levafour. On the Time of Demagnetisation of Soft Iron, by W. C. Hodgkins and J. H. Jennings. Light transmitted by one or more Plates of Glass, by W. W. Jacques. On the Application of Logical Analysis to Multiple Algebra, by C. S. Peirce. On the Uses and Transformations of Linear Algebra, by Benjamin Peirce. On a New Optical Constant, and on a Method of Measuring Refractive Indices without the use of Divided Instruments, by Wolcott Gibbs, M.D. Intensity of Twilight, by Charles H. Williams. Light of the Sky, by W. O. Crosby. Light absorbed by the Atmosphere of the Sun, by E. C. Pickering and D. P. Strange. Tests of a Magneto-electric Machine, by E. C. Pickering and D. P. Strange. Answer to M. Jamin's Objections to Ampère's Theory, by William W. Jacques. Melanosiderite: a New Mineral Species, from Mineral Hill, Delaware County, Pennsylvania, by Josiah P. Cooke, jun. On Two New Varieties of Vermiculites, with a Revision of the other Members of this Group, by Josiah P. Cooke, jun., and F. A. Gooch.

AT a meeting of the Council of the Royal School of Mines, held on Saturday, July 3rd, the following gentlemen received the diploma of Associate of the Royal School of Mines:—Mining and Metallurgical Divisions: Harry H. Becher, W. Frecheville, F. H. Marshall, Ambrose R. Willis. Mining Division: Archibald E. Pinching, G. Seymour, H. Lamont Young. Metallurgical Division: G. Fitz Brown, Robert Hellon, W. Foulkes Lowe, Thomas Purdie. Geological Diivsion: G. C. Frames. The following scholarships and prizes were also awarded:—Third-year Students: The De la Beche Medal and prize of books to Mr. G. Fitz Brown; the Murchison Medal and prize of books for Geology to Mr. G. Seymour. Second-year Students: H.R.H. the Duke of Cornwall's Scholarship of 30*l*. for two years to Mr. H. Louis, and the Royal Exhibition of 25*l*. to Mr. W. Hewitt. First-year Students: Two Royal Scholarships of 15*l*. each to Mr. A. N. Pearson and Mr. L. J. Whalley.

DURING the past week the Commission on Vivisection have held several meetings. The absence of Prof. Huxley is to be regretted.

IN the secret committee which was held after Monday's sitting of the Paris Academy of Sciences the claims of M. Mouchez and M. Wolf to the vacant membership in the section of Astronomy were warmly discussed. The election will probably take place next Monday. M. Mouchez is one of the most successful of the Transit observers, and M. Wolf is the sub-director of the Paris Observatory.

A SECOND specimen of a Two-horned Asiatic Rhinoceros was yesterday deposited in the Zoological Society's Gardens. It closely resembles the Hairy-eared species, and does not differ much from the Sumatran animal.

A SECOND edition has been issued of "The Unseen Universe; or, Physical Speculations on a Future State" (Macmillan and Co.)

THE Geologists' Association will make a five days' excursion into East Yorkshire, commencing on July 19.

IN connection with the calamitous floods around Toulouse, on the 25th June a singular phenomenon was observed at Clermont-sur-Lanquet. The whole of the earth on the slope of a mountain was moved bodily, a shepherd's house being transported uninjured to a distance.

WE have received a paper addressed to the Royal Society of Edinburgh by M. F. Lefort, Inspecteur-Général des Ponts et Chaussées, containing Observations relative to Mr. Edward Sang's "Remarks on the Great Logarithmic and Trigonometrical Tables calculated in the Bureau du Cadastre under the direction of Prony." Appended to the paper is Mr. Sang's reply to M. Lefort's observations.

WE have received the "Astronomical and Meteorological Observations" made during the year 1872 at the U.S. Naval Observatory.

To those who are interested in the question of the pollution of rivers, we would commend a letter to the Right Hon. G. Sclater-Booth, President of the Local Government Board, entitled "The Pollution of Rivers, by a Polluter" (Mr. E. C. Potter, of Manchester). In a very moderate and reasonable way it advances some arguments in favour of the polluter's side of the question.

THE Thirteenth Annual Report of the Birmingham Free Libraries Committee for 1874 is on the whole a satisfactory one. The aggregrate number of issues for the year is 542,887, and although this is only an increase of about 3,000 over 1873, there is a very marked increase in the issues of books to readers in the Reference Library, indicating the growing use of a higher class of works than are deposited in the Lending Library, and showing that the Free Library system is bearing fruit in raising the standard of taste and cultivation among readers. The issue of scientific works both in the Lending and Reference Libraries bears a very fair proportion to that in other departments.

WE have received a paper by Mr. W. W. Wagstaffe, of St. Thomas's Hospital, on the mechanical structure of the cancellous tissue of bone, in which the arrangement of the trabeculæ of the articular ends of the human bones are described, from sections, on the same principle as that previously adopted by Mr. F. Ward, Julius Wolff, and others.

THE additions to the Zoological Society's Gardens during the past week include a Maholi Galago (*Galago maholi*) from S. Africa, presented by Mr. C. E. Thomson; two Angulated Tortoises (*Chersina angulata*) from S. Africa, presented by Mr. L. A. Knight; a Roseate Cockatoo (*Cacatua roseicapilla*) from Australia, presented by Mr. Alfred Thompson; seven Garganey Teal (*Querquedula circia*), and a Temminck's Tragopan (*Ceriornis temmincki*) from China; two Argus Pheasants (*Argus giganteus*) from Malacca, deposited; two Giant Tortoises (*Testudo indica*) from the Aldabra Islands, purchased; a Malbrouck Monkey (*Cercopithecus cynosurus*) from W. Africa, received in exchange; a Hog Deer (*Cervus porcinus*) and five Chiloe Wigeons (*Mareca chiloensis*) born in the Gardens.

## SCIENTIFIC SERIALS

*Transactions of the Norfolk and Norwich Naturalists' Society*, vol. ii. part i., 1874-5.—This Society has now been in existence for seven years, and at present numbers 140 members. It endeavours, we believe, faithfully to carry out one of the main objects of local societies, the study of the natural history of its district. This number of its Transactions contains the first section, Dicotyledonous, of a list of the flowering plants of Norfolk, forming the sixth instalment of the fauna and flora of the county, which the Society is publishing. Mr. John Quinton also contributes "Notes on the Meteorological Observations recorded at Norwich during 1874." A notable and excellent feature in this Society's publications is the miscellaneous notes, in which are briefly recorded new or interesting facts in the natural history of the county. There are several curious papers in this part. Mr. Amyot gives some details concerning a very old oak at Winfarthing Manor.—Mr. J. H. Gurney communicates some extracts from the notebook of the late Miss Anna Gurney of Northreps, in which she recorded noteworthy zoological occurrences in her neighbourhood, between 1820 and 1856.—A reprint of a letter by Sir J. E. Smith, from vol. vii. of the *Transactions* of the Linnean Society, gives some interesting details concerning several Norwich botanists.—Mr. T. Southwell contributes an analysis of the documents from which the "Indications of Spring," communicated to the Royal Society by Robert Marsham, F.R.S., in 1789, were compiled.—A list of 139 birds observed on the Kimberley estate, by the Earl of Kimberley.—The wild cattle at Chillingham, by Mr. C. G. Barrett, an interesting account of a visit to those rare animals.

*Journal of the Franklin Institute*, May.—The following are the principal papers in this number: "On the theory of the tension of belts," by Prof. L. G. Franck; the continuation of Mr. C. E. Emery's paper on "Compound and non-compound engines," and of Chief Engineer B. F. Isherwood's paper on "Experiments with different screws;" "On the mechanical equivalent of heat," the translation of a paper by M. Jules Violle. There is also a description of the Centennial Exhibition Buildings, with some excellent views, plans, and elevations.

*Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie*, May 15.—The first paper describes a new kind of thermometer invented by Dr. Wollny, of Munich, for earth-temperature between 0·3 and 1·8 metres below the surface.—The next is the concluding part of Mr. Colding's article on winds. After explaining the effect of the rotation of the earth on great atmospheric currents, he continues as follows:—Let us consider the case of two winds, a polar and an equatorial, moving side by side in opposite directions, the polar being to the west of the other. Clearly the two will have a tendency to recede from each other, and in consequence there will be rarefaction at their neighbouring borders, producing a reaction in the two currents exactly counterbalancing the force due to rotation. Thus pressure diminishes from their outer towards their inner or neighbouring borders, where there must be a valley or depression of their surfaces. Since the magnitude of this valley depends upon the velocity of the winds, any slackening of velocity in one of them must allow it to break into the other by gravitation, and originate a hurricane revolving against the sun. It is the denser polar wind which generally breaks into the equatorial from a N.W. direction. Condensation of vapour follows, and then under certain conditions a hurricane. Now to take the other case—what will happen if the polar current flows on the east of the equatorial? The effect of the rotation of the earth will be a heaping up or condensation of air at their neighbouring borders, and the heavier current as before will invade the lighter from S.E., bringing rain. Here, however, there can be no hurricane, for gravitation acts dispersively, and the adjustment of level proceeds outwards instead of inwards. If it were possible for a hurricane to arise on the east side of the equatorial current, it would rotate "with the sun." The reason why all hurricanes rotate against the sun is now obvious. With these principles in mind, Mr. Colding thus illustrates the law of Dove: Let us imagine ourselves advancing in a westward direction out of a polar into an equatorial current. The wind turns gradually to E., then it changes to S. and S.W. as we enter the warm current; then we have it W., N.W., N., and finally N.E., in the polar current on the other side. Now at most stations where observations have been made, this direction of shift is the common one. Hence we are led to suppose that the atmosphere as a whole moves sometimes from E. to W., but more commonly from W. to E. There is good reason for this view. If the atmosphere consisted of air only, there would be no reason for an excess of eastward movement, but the equatorial current, more than the polar, carries a large quantity of vapour, and this causes an excess of pressure from W. to E. Therefore, concludes the author, Dove's law is a real law of nature.

June 1.—The chief papers in this number bear the following titles:—"The Climate of the Lower Yenesei," "Co-efficients of Temperature of Naudet's Aneroid," "An empirical demonstration of the Motive Force of the Equatorial Oceanic Current," "Quantity of Carbonic Acid Gas in Desert Air." The last paper refers to an examination of the air of the Libyan desert, by which it appears that the quantity of carbonic acid gas contained by it is about the amount found in other open places.

*Reale Istituto Lombardo*, Rendiconti, t. 8, fasc. iii., iv., e v.—These parts contain the following papers:—Prof. L. Maggi and G. Cantoni, on some new experiments on heterogeneity and some consequences drawn from previous series of experiments.—On the modification of the pupil observed in some cardialgies, by Dr. A. de Giovanni.—Researches on the morphogeny of alcoholic ferments, by Dr. J. Macagno.—Meteorological observations made at the Observatory of Brera, by Abate G. Capelli.—On some new parasitic fungi found by Dr. A. Cattaneo, of the Cryptogamic Laboratory, on some fruit affected by the so-called rosin disease and gangrene, by Prof. S. Garovaglio; the fungi belonged to the families of *Sporocadus sphæronema*, *Echinobotryum*, and a new kind called *Cattanea*; and the part contains some excellent illustrations of the species.—A note by Prof. C. Combroso on the causes of crime.—On the physiological effects of the *Jaborandus*, a shrub growing in the interior of some provinces of Northern Brazil, and whose leaves much resemble those of laurels, by Dr. Carlo Ambrosoli.—On the correction of temperature in a liquid into which the thermometer cannot be sufficiently immersed, by Prof. Rinaldo Ferrini.—On the centre of gravity in some homogeneous systems, by Prof. G. Bardelli.—Observations of the periodical comet of Winnecke (1819, III.), by Prof. G. V. Schiaparelli, made at the Observatory of Brera.

*Freiburg Naturforschende Gesellschaft*.—This Society's *Verhandlungen* (vol. vi. Parts I.-III.) contain the following more important papers:—On the action of sulphur chloride upon aniline in the presence of carbon bisulphide, by A. Claus and W. Krall.—On the action of solids upon over-saturated solutions, by F. C. Henrici.—On the occurrence and some reactions of pyrol, by W. Schlebusch.—On the decomposition of grape sugar by cupric oxide in alkaline solution, by A. Claus.—On some volcanic rocks of Java (with plates), by H. Rosenbusch.—On nitrophenylene, by A. Claus.—Microscopic mineralogical researches, by H. Fischer (second paper).—On the galvanic ignition of metal wires, by Dr. J. Müller.—A graphic representation of Ohm's law; notes on melting points; both these papers by the same.—On Diiodohydrine, by A. Claus.—Researches on the Lesser Lamprey (*Petromyzon planery*), by Dr. P. Langerhans (with plates).

THE *Gazzetta Chimica Italiana*, fasc. iv., 1875, contains the following original papers:—On the hydrate of chlorine $Cl_2 + 10H_2O$, by U. Schiff.—On the action of aniline on dichlorhydrine, by the same.—On the supposed transformation of the asparagine of vegetables into an albuminoid, by M. Mercadante.—Besides the above there is a literal translation of Prof. Clerk-Maxwell's paper on the dynamic evidence of the molecular constitution of bodies, as read at the Chemical Society in February last, and a summary of the contents of other journals.

THE "*Annali di Chimica applicata alla Medicina*" (April) contains the following papers:—On chloral-collodion, by C. Pavesi.—On the action of water upon subnitrate of bismuth, by A. Ditte.—On the morphogeny of alcoholic ferments, by Dr. J. Macagno.—On the action of nitrite of amyl upon the blood corpuscles, and on the temperature of the body during the inhalation of this substance, by W. B. Woodmann.—On the origin and propagation of disease (last paper), by Sig. Calton.—On the nature of hydrophobia, by Dr. Brunetti.

*Archives des Sciences Physiques et Naturelles*, No. 209, May 15.—The following are the principal original papers contained in this number:—On Anæsthetics, by Dr. J. L. Prevost. Reply to that part of M. Marc Micheli's article on the progress of botany in 1874 which concerns plant-motion, by E. Hæckel.

—On the normal spectrum of the sun, the ultra-violet part, by M. A. Cornu, with a plate.

*Nachrichten von der Königl. Gesellschaft der Wissenschaften und der G. A. Universität zu Göttingen* (Nos. 11-16, 1875).—From these publications we note the following papers:—Researches on the magnetism of steel rods, by Dr. Carl Fromme.—On the oscillations of a magnet under the resisting influence of a copper ball, by Franz Himstert.—On the determination of the specific conducting resistance of gas coal, by Ed. Riecke.—On hyperelliptical integrals, by L. Koenigsberger.—On the irregularities and fundamental numbers of plane curves of the third order with points, by Dr. Hermann Schubert.—On the symmetric functions of weight (XI.), by Prof. Faa de Bruno.—On the volcanic ashes of Turrialba (Costa Rica), by Heinr. O. Lang.—On the structure of German ferns, by H. Conwentz.

*Göttingen Royal Society of Sciences.*—Nos. 1 to 10 of this society's *Nachrichten* contain the following among other papers: On some cut stones (flints) hitherto unknown, by Fr. Wieseler.—On elastic after effects, by Fr. Kohlrausch.—On Asa Grey's group of *Diapensiaceæ*, by Dr. O. Drude.—On a new genus of Palmæ of the Arecineæ group, called *Grisebachia*, by the same and H. Wendland.—On the proof of Cauchy's theorem for complex functions, by G. Mittag-Leffler.—On the curvature of some planes, by A. Enneper.—On Rabuteau's law of the toxical effect of elements and the action of lithium, by Prof. Husemann.—On a fundamental theme of Plücker's geometry, by Dr. A. Voss.—On the ends of sensitive nerves in the skin, by Prof. F. Merkel.—On dibromobenzoic acids, by A. Burghard.—On iodosulphotoluol, by H. Glassner.—On mononitrobenzonaphtylamines, dinitrobenzonaphtylamide and their derivatives, by P. Ebell.—On *Fucus vesiculosus*, by J. Reinke.—On the action of a weak acid upon the salt of a stronger acid, by H. Hübner and H. Wiesinger.—On magnetism in steel rods, by Herr Fromme.—On the specific resistance of gas-coal, by Herr Schrader.

## SOCIETIES AND ACADEMIES

### London

**Geological Society**, June 23.—Mr. John Evans, V.P.R.S., president, in the chair.—Some observations on the Rev. O. Fisher's remarks on Mr. Mallet's theory of volcanic energy, read May 12, 1875, by Robert Mallet, F.R.S. The subject of the Rev. O. Fisher's paper has been anticipated by one from Prof. Hilgard (Geol. Univ. of Michigan) published in the *American Journal of Science* (vol. vii., June 1874). The pith of the Rev. O. Fisher's communication is to a great extent comprised in the two following sentences:—1. That "if crushing the rocks can induce fusion, then the cubes experimented upon ought to have been fused in the crushing?" 2. "If the work (of crushing) is equally distributed throughout, why should not the heat be so also? or if not, what determines the localisation?" In his reply Mr. Mallet controverts the views of the Rev. O. Fisher by bringing them into contact with acknowledged physical laws. He shows that "crushing alone of rocky masses beneath our earth's crust may be sufficient to produce fusion. He also shows that the heat developed by crushing alone cannot be equally diffused throughout the mass crushed, but must be localised, and that the circumstances of this localisation must result in producing a local temperature far greater than that due to crushing. Lastly, he shows that after the highest temperatures have been thus reached, a still further and great exaltation of temperature must arise from detrusive friction and the movements of forcible deformation of the already crushed and heated material." He therefore expresses his conviction that "there is no physical difficulty in the conception involved in his original memoir (Phil. Trans. 1873), but not there enlarged upon in detail, that the temperatures consequent upon crushing the materials of our earth's crust are sufficient locally to bring these into fusion."

On the physical conditions under which the Cambrian and Lower Silurian rocks were probably deposited over the European area, by Mr. Henry Hicks. The author indicates that the base line of the Cambrian rocks is seen everywhere in Europe to rest unconformably upon rocks supposed to be of the age of the Laurentian of Canada, and that the existence of these Pre-Cambrian rocks indicates that large continental areas existed previous to the deposition of the Cambrian rocks. The central line of the Pre-Cambrian European continent would be shown by a line drawn from S.W. to N.E. along the south coast of the English Channel, and continued through Holland and Denmark to the Baltic. Its boundaries were mountainous; they are indicated in the north by the Pre-Cambrian ridges in Pembrokeshire, in the Hebrides and Western Highlands, and by the gneissic rocks of Norway, Sweden, and Lapland. The southern line commenced to the south of Spain, passing along Southern Europe, and terminated probably in some elevated plains in Russia. Between these chains the land formed an undulating plain, sloping gradually to the south-west, its boundary in this direction being probably a line drawn from Spain to a point beyond the British Isles, now marked by the 100-fathom line. The land here facing the Atlantic Ocean would be lowest, and would be first submerged when the slow and regular depression of the Pre-Cambrian land took place. The author points out that the evidence furnished by the Cambrian and Lower Silurian deposits of Europe is in accordance with this hypothesis. In England they attain a thickness of 25,000 to 30,000 feet; in Sweden not more than 1,000 feet; and in Russia they are still thinner, and the earlier deposits seem to be wanting. In Bohemia they occupy an intermediate position as to thickness and order of deposition. The author discusses the phenomena presented by the Welsh deposits of Cambrian and Lower Silurian age, and shows that we have first conglomerates composed of pebbles of the Pre-Cambrian rocks, indicating beach conditions, then ripple-marked sandstones and shallow-water accumulations, and then, after the rather sudden occurrence of a greater depression, finer deposits containing the earliest organisms of this region, which he believes to have immigrated from the deep water of the ocean lying to the south-west. After this the depression was very gradual for a long period, and the deposits were generally formed in shallow water; then came a greater depression, marked by finer beds containing the second fauna; then a period of gradual subsidence, followed by a more decided depression of probably 1,000 feet, the deposits formed in this containing the third or "Menevian" fauna. This depression enabled the water to spread over the area between the south of Prussia and Bohemia and Norway and Sweden, there being no evidence of the presence of the first and second faunas over this area. The filling up of this depression led to the deposition of the shallow-water deposits of the Lingula-Flag group, followed by another sudden depression at the commencement of the Tremadoc epoch, which allowed the water to spread freely over the whole European area. The author next discusses the faunas of the successive epochs, and indicates that these are also in favour of his views. He indicates the probability that the animals, which are all of marine forms, migrated into the European area from some point to the south-west, probably near the equator, where he supposes the earliest types were developed. Both the lower and higher types of invertebrates appear first in the western areas; and the groups in each case as they first appear are those which biologists now recognise as being most nearly allied, and which may have developed from one common type. The lower invertebrates appear at a very much earlier period than the higher in all the areas. In the Welsh area the higher forms (the Gasteropods, Lamellibranchs, and Cephalopods) come in for the first time in Lower Tremadoc rocks; and with the exception of the presence of a Gasteropod in rather lower beds in Spain, this is the earliest evidence of these higher forms having reached the European area. At this time, however, no less than five distinct faunas of lower invertebrates had already appeared; and an enormous period, indicated by the deposition of nearly 15,000 feet of deposits, had elapsed since the first fauna had reached this area. The author points out also that a similar encroachment of the sea and migration of animals in a north-westerly direction occurred in the North American area at about the same time, the lines indicating the European and American depressions meeting in Mid-Atlantic.

On a Bone-cave in Creswell Crags, by the Rev. J. Magens Mello. In this paper the author describes some fissures containing numerous bones, situated in Creswell Crags, a ravine bounded by cliffs of Lower Permian limestone on the north-eastern borders of Derbyshire. These cliffs contain numerous fissures. The principal one described by the author penetrates about fifty yards into the rock, and has a wide opening, but is very narrow throughout the greater part of its length. It runs nearly north and south, and inclines slightly from west to east from the top downwards. The organic remains found in the first fissure belong to fourteen mammals at least, besides a bird and a fish. The mammalia are: Man, *Lepus timidus*, *Gulo luscus*, *Hyæna spelæa*, *Ursus*, sp., *Canis lupus*, *Canis vulpes*, *Canis lagopus*, *Elephas primigenius*, *Equus caballus*, *Rhinoceros ticho-*

*rhinus, Bos urus, Cervus megaceros, Cervus tarandus, Ovis*, sp., *Arvicola*, sp.

Notes on Haytor Iron Mine, by Clement Le Neve Foster, D.Sc.

On the formation of the Polar Ice-cap, by Mr. J. J. Murphy. The present paper is intended by the author to supplement a previous one read before the Society in 1869 (Q. J. G. S., vol. xxv. p. 350), in which he gave reasons for differing from Mr. Croll in thinking that the glacial climate was one of intense cold, and held, on the contrary, that it was one of snowy winters and cold summers, with a small range of temperature. Mr. Campbell, in a paper read before the Society in 1874, gave the following as the southernmost limits of the polar ice-cap, viz. :—In Eastern Europe, lat. 56° N. ; in Germany, 55° ; in Britain, nearly 50° ; in America, 39°. This the author considers as strong but not new evidence against the theory of ice-cap extending to low latitudes ; the extent of the ice-cap would of course not be so wide as that of the limits of glaciation, owing to the floating ice approaching nearer the equator. After commenting on Mr. Belt's remarks made during the discussion of Mr. Campbell's paper, the author states that he attributes the presence of the boulders found in the valley of the Amazon to icebergs which had drifted further than usual. The glaciation of the tropics would imply the glaciation of the whole world, which appears no more possible than that the whole world was submerged at one time. The author concludes with some remarks on a recent paper of Mr. Tylor's.

Notes on the Gasteropoda of the Guelph Formation of Canada, by Prof. H. Alleyne Nicholson, D.Sc., F.R.S.E. The author notices the occurrence of the Guelph formation as a subdivision of the Niagara series in Canada and the United States, and describes it as consisting everywhere of a cellular, yellowish, or cream-coloured dolomitic limestone of rough texture and crystalline aspect, containing innumerable cavities from which fossils of various kinds have been dissolved out. In this paper the author describes all the known Gasteropoda of the Guelph formation in Canada, including the following previously described species :—*Murchisonia Loganii* (Hall), *M. turritiformis* (Hall), *M. macrospira* (Hall), *M. bivittata* (Hall), *M. longispira* (Hall), *M. vitellia* (Billings), *M. Hercyna* (Billings), *Cyclonema? elevata* (Hall), *Holopea guelphensis* (Billings), *H. gracia* (Billings), *Subulites ventricosus* (Hall), and *Pleurotomaria solarioides* (Hall). As new species he describes *Murchisonia Boylei*, distinguished from *M. turritiformis* (Hall) and *M. estella* (Billings) by its more rapid rate of expansion, its apparently canaliculated suture, and the existence of an angular band a little above the suture ; and *Holopea? occidentalis*, distinguished by its short but elevated spire, its large body-whorl, which becomes almost disjunct at the aperture, its circular aperture, and large umbilicus. The upper whorls are convex, but the body-whorl is obtusely angulated at about its upper fourth. Uncertain species of *Murchisonia* and *Pleurotomaria* are also indicated.

Description of a new genus of Tabulate Coral, by Mr. G. J. Hinde. The coral described by the author as constituting a new genus of Favositidæ, for which he proposes the name of *Sphærolites*, has a massive free corallum consisting of minute, polygonal, closely united corallites, growing in all directions from a central point, forming a spheroidal body, the entire surface of which is occupied by the calices of the corallites. The walls of the corallites are very delicate, with numerous pores ; the tabulæ are incomplete, formed by delicate arched lamellæ, and there are no septa. From *Chætetes* this genus is distinguished by the perforated walls and incomplete arched tabulæ ; from *Favosites* it differs in its mode of growth and its incomplete tabulæ ; and from *Michelinia* it is separated by the minuteness of its corallites, and the absence of epitheca and of septal striæ. The single species, which is named *S. Nicholsoni*, is from calcareous shale of Lower Helderberg (Ludlow) age, near Dalhousie, in New Brunswick.—(*To be continued.*)

**Physical Society**, June 26 (continued from p. 179).—Prof. G. C. Foster, vice-president, in the chair.—Prof. G. C. Foster called attention to the work of Prof. Everett on the Centimetre-gramme-second (C.G.S.) System of Units which will shortly be published by the Society. It is designed to facilitate the study of the quantitative relations between the different departments of physical science by the adoption of a common system of units. Prof. Foster explained that a committee of the British Association which was appointed in 1872, and of which Prof. Everett was secretary, recommended the adoption of this system, based upon the metric system, the unit of *mass* being the gramme, that of *length* the centimetre, and that of *time* the second. They recommended that the unit of force be called a *dyne*, which therefore is the force required to act upon a gramme of matter for a second to generate a velocity of a centimetre per second. The unit of work is called an *erg*, and is the amount of work done by a dyne working through the distance of a centimetre. Prof. Everett's book consists of a collection of physical data reduced to these fundamental terms, so that no other physical magnitudes enter into the expressions, and it cannot fail to prove of the greatest possible value to physicists. Prof. Foster then left the chair, which was taken by Dr. Stone.—Dr. W. M. Watts communicated a paper on a new form of micrometer for use in spectroscopic analysis. In determining the positions of lines in a spectrum by the use of a micrometer eye-piece or divided arc, it is often difficult to see the cross wires distinctly without admitting extraneous light, which with faint spectra frequently cannot be done. Dr. Watts has sought to overcome this difficulty by substituting some one known line of the spectrum itself for the cross wires, and to measure the positions of unknown lines by bringing this index line successively into coincidence with them. Thus, for example, the sodium line, which is present in nearly every spectrum whether it is wanted or not, may be made to move slowly when under the spectrum, and the displacement necessary to make it coincide with the lines to be measured may be determined by the readings of a micrometer screw. To accomplish this a convex lens of about two-feet focus is placed in front of the prism of the spectroscope, between the prism and observing telescope, and is divided along a line at right-angles to the refracting edge of the prism. One half of the lens is fixed, the other half is made to slide over it by means of a micrometer screw. When the movable half of the lens is in its normal position, the only effect is to alter the focus of the telescope slightly, but when it is made to slide over the fixed half, the refraction of the prism is increased or diminished, and half of the spectrum appears to move over the other half, and the sodium line, or any other convenient line of reference can be brought into coincidence with the lines to be measured. The indications of this instrument are reduced to wave-lengths by means of a series of interpolation curves from the data obtained by observations of the solar spectrum, the coordinates of which are wave-lengths and micrometer readings. The author considers the advantages of the instrument to be (1) great precision in results ; and (2) convenience in use. In illustration of the former quality he quotes twenty readings of the point at which there is coincidence of the lenses. They are remarkably concordant, the mean being 8·34, while the two extreme readings are 8·21 and 8·41—Prof. Guthrie then read a paper on the fundamental water-waves in cylindrical vessels. He stated that many attempts had been made to connect wave-lengths with wave-amplitude, and that the most successful of these were by the brothers Weber, who allowed a column of water to fall into one end of a long trough filled with water ; and they ascertained by means of a stop-watch when the crest of the wave reached the other end. Dr. Guthrie has recently made some experiments on this subject, in which he employed a series of five vessels, varying in diameter from 5·5 to 23·5 inches. The water in each was agitated in the centre by a disc of wood, by which means the vessel was made to give what Dr. Guthrie called its "fundamental note." He counted the number of times the wave rose in the centre in a minute, and he found that amplitude has no influence upon the rate. It should also be observed that the wave effect is not the same as if the field were of infinite extent. The following are the results he obtained :—

| | Diameter of vessel. | No. of pulsations per minute. |
|---|---|---|
| (1) | 23·5 inches. | 106·5 |
| (2) | 17·87 „ | 122·7 |
| (3) | 14·5 „ | 136·0 |
| (4) | 12·5 „ | 146·5 |
| (5) | 5·5 „ | 219·0 |

From which he deduced the curious result that a constant quantity (517·5) is obtained by multiplying the square root of the diameter by the number of pulsations. The question of depth was also carefully considered, and it was ascertained that the number of waves increases slightly with the depth.—Mr. S. C. Tisley read a paper on a new form of magneto-electric machine. After briefly describing the machines which have

hitherto been devised, he stated that the new apparatus consists essentially of an electro-magnet with shoes forming a groove, in which a Siemens' armature is made to revolve. It differs from the original machines made by Siemens and Wheatstone in the commutator, as two springs conduct the current from the cylindrical insulator, to which are attached three pieces of metal, one surrounding it for three-quarters of its circumference, the second for one quarter, and between these is a ring connected with the insulated end of the wire from the armature, and bearing two pieces of metal which are so arranged as to complete the circles of the outer pieces of metal. The armature is so constructed that a stream of water may be constantly passed through it. A small machine constructed on this principle, which without its driving gear weighs 26 lbs., is capable of raising 8 inches of platinum wire 8 inches long and ·005 inches in diameter to a red heat.—Dr. Stone then adjourned the meetings of the Society until November.

VIENNA

**Imperial Academy of Sciences**, Jan. 14.—The following papers were read:—On the tempera- tures arising from the mixing of sulphuric acid with water, with reference to the molecular heats and boiling points of the resulting hydrates, by Dr. L. Pfaundler.—On the occurrence of relatively high temperatures of air in the valleys of the Alps, by Prof. Kerner.—On some researches on dinitro compounds of the phenyl series, by Prof. Hlasiwetz. The author shows that phenol can easily be converted into dinitrophenol if treated with nitrous acid when dissolved in ether. At the same time mononitrophenol is formed—

(1) $C_6H_5 . OH + N_2O_3 = C_6H_4N_2O + N_2O_5 + H_2O$
(2) $2C_6H_5 . OH + N_2O_5 = 2C_6H_4 . NO_2 . OH + H_2O$.

—Prof. Weiss then gave an account of his observations of the transit of Venus at Jassy. The inner contact could not be observed through clouds, but the outer one was observed at 20h. 25m. 49s·7 Jassy mean time. Prof. Weiss thinks that through the unsatisfactory state of the atmosphere this result may probably not be quite correct, and that the actual contact took place a few tenths of a second later. The longitude of the observing station was found to be 44m. 49s.·7 east of the Imperial Observatory of Vienna (probable error in this = ± 0s·1).—Prof. Oppolzer gave an account of his observations at the same place, and quoted his results in Paris mean time. In the reports of the Academy for April 1870 he had given the time for the second outer contact 18h. 45m. 25s.·7 Paris mean time; he found by observation 18h. 44m. 56s.·3 Paris mean time; difference, 29s.·4. The latitude of Jassy is given as + 47° 9′ 25″·1 (± 0″·2).

Jan. 21.—The following papers were read:—A note on the experimental determination of diamagnetism by means of its electric action of induction, by Prof. Toepler.—On the action of the muscular current upon a secondary circle of currents, and on a peculiarity of currents of induction, induced by a very weak primary current; by Prof. Brücke.—On some *Acara* and *Geophagus* species of the Amazon River, by Dr. Steindachner; in a second paper this gentleman spoke of four new Brazilian siluroids, belonging to *Oxydoras*, *Doras*, and *Rhinodoras*.

Feb. 4.—On the double refraction of quartz under pressure, by Prof. Mach.—On the latent heat of vapours, by Prof. Puschl.—On the fine structure of bones, by Prof. v. Ebner.—Detailed classification of all known Foraminifera, by A. v. Reuss.—Researches on the development of Naiades (freshwater mussels), by W. Flemming.—On the dependence of the coefficient of friction of the air upon temperature, by A. v. Obermayer.

Feb. 18.—On phenomena of flexion in the spectrum, by W. Rosicky.—On the temperatures of solidification of the hydrates of sulphuric acid and the composition of the crystals formed, by Prof. Pfaundler and E. Schnegg.

Feb. 25.—On the Tertiary strata on the north side of the Apennines from Ancona to Bologna, and on the Pliocene formations of Syracuse and Lentini, by Th. Fuchs and A. Bittner.

March 11.—On the great ice period, and on some geological theories, by Dr. A. Boué.—On anthracene and its behaviour towards iodine and mercuric oxide, by Dr. H. Hlasiwetz and Dr. O. Zeidler.

March 18.—On a consequence drawn from Biot-Savart's law, by Prof. A. Wassmuth.—On the thermoelectric behaviour of metals during melting and solidification, by A. v. Obermayer.

STOCKHOLM

**Kongl. Vetenskaps Akademiens Förhandlingar**, Jan. 13.—The following papers were read:—On the relation of temperature and moisture in the lowest strata of the atmosphere at daybreak, by R. Rubenson.—On the efflorescence of alum salts and their influence on vegetation, by C. E. Bergstrand.—On the conduction of heat in a cylinder, by G. Lundquist.—On the situation of moraines and terraces on the banks of many inland lakes, by A. Helland (with plate).—*Insecta Transvaalensia*, a contribution to the insect fauna of the Transvaal Republic, South Africa, by H. D. J. Wallengren.—On the low vegetation of Omberg, by P. G. E. Theorin. These papers are all in Swedish, with the exception of that by A. Helland, which is in the Danish language.

PARIS

**Academy of Sciences**, July 5.—M. Frémy in the chair.—The following papers were read:—A note by M. Chevreul, on the explanation of numerous phenomena which are a consequence of old age. This is the abstract of a third memoir on the subject.—On the distribution of magnetism in bundles of an infinite length composed of very thin laminæ, by M. J. Jamin.—Second note on tabular electro-magnets with multiple cores, by M. T. du Moncel.—The rain of Montpelier during twenty-three years (1852–74), from observations at the Jardin des Plantes, by M. Ch. Martins.—On the Devonian period in the Pyrenees, by M. A. Leymerie.—A letter was read from P. Secchi, accompanying the presentation of the second French edition of his work on the Sun.—Description of the group of the Pleiades and micrometric measurements of the positions of the principal stars which compose it, by M. Wolf. The author employed an object-glass of 0·31m. aperture, the positions being given to one-tenth of a minute of arc. The catalogue comprises 499 stars from the 3rd to the 14th magnitude, contained in a rectangle 135 min. long, and 90 min. broad, η Tauri occupying the centre. All the stars in the group are referable to P. Secchi's first type with regard to their spectra. The differences between the author's measurements and those of Bessel seem to point to the conclusion that the group has a proper motion towards the north-west.—Researches on carbon monosulphide, by M. Sidot. According to the author, this substance is formed by the prolonged action of light on carbon disulphide. It is described as a reddish brown powder possessing neither taste nor smell. Analyses gave numbers agreeing with the required formula CS.—On atmospheric currents, by M. J. A. Broun.—Phylloxera in the Department of Gironde, by M. Azam.—Planet 146 Lucine. Elements of the orbit calculated, by M. E. Stéphan.—On the processes of magnetisation, by M. J. M. Gaugain.—The nut from Bancoul. Chemical studies of the oleaginous fruits of tropical countries, by M. B. Corenwinder.—On the gum in wine and its influence on the determination of the glucose, by M. G. Chancel.—Chlorobrominated ethylene: isomerism of its chloride and the bromide of perchlorinated ethylene, by M. E. Bourgoin.—Influence of chalk on the distribution of the so-called "calcifuge" plants, by M. C. Contejean.—On the absorption of coloured liquids, by M. Cauvet.

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